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Work measurement of Navy supply functions : an evaluation of techniques and applications.

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WORK MEASUREMENT OF NAVY SUPPLY FUNCTIONS
AN EVALUATION OF TECHNIQUES AND
APPLICATIONS

by

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CHAPTER I

INTRODUCTION

Since 1950 the development and application of work measurement systems in the Federal Government, particularly the Department of Defense, have increased significantly. Today, in many areas of Navy supply management, the manager is faced with not one but several programs or systems designed to provide him with workload and manpower performance data. Some of these work measurement systems appear duplicative and overburdensome. It is the manager who is responsible for their implementation, maintenance and utilization. It is also the manager who will gain or suffer the most from their employment. Some managers are reluctant to recognize and hesitant to use work measurement as a management tool for manpower utilization and control. At the same time they are confronted with the ever persistent problem of attaining optimum levels of operating effectiveness and manpower staffing. Efforts abound to develop and apply new techniques and concepts to provide the manager with the means of achieving maximum economy of manpower while improving operating effectiveness. He cannot escape from the requirement for some form of work measurement. What kind of work measurement system should a manager seek to employ?

Statement of the Problem

It is the purpose of this paper to develop and outline the requisite components and cogent applications of a fully integrated work measurement system for Navy supply functions. This projected system is established on a foundation of analysis and understanding developed by answering some fundamental questions.

Basic to the employment of any work measurement system are the measurement techniques themselves. What are the major measurement techniques used in work measurement? What are their advantages and limitations?

The examination of existing work measurement programs and systems is most helpful in attacking the problem of further development and improvement. What are some of the more significant applications of work measurement to Navy supply functions? What are their major features and how do they relate (overlap, duplicate) to each other?

The answers to these questions are used to develop and support a fully integrated work measurement system that is in recognition of the needs of management, the current organizational and system environment, and technical characteristics of work measurement techniques and applications. The question of what kind of work measurement system a manager should employ may never be satisfactorily answered. This thesis is expected to contribute to an understanding of some of the problems involved and provide one approach to their solution.

Scope of the Study

The scope of this paper is limited to the examination of work measurement as it applies to the work performed in the Navy supply functional areas. Only those aspects of work measurement application relating to administrative, clerical and material handling functions are included. The choice of this area of interest centers around two basic reasons. First, these functions have been subjected to exhaustive coverage by various and essentially different kinds of work measurement systems. The three different systems studied in this paper are presently being actively pursued in the several functions of supply operations at Navy stock points. The second reason is that this author has experience in supply operations and with all three work measurement systems. The three systems are: The Naval Supply System Command Supply Management Report (Work Measurement); The Defense Integrated Management Engineering Systems (DIMES); and the Department of Defense Warehousing Gross Performance Measurement System (WGPMS).

No attempt was made to examine or evaluate the supply system or the functions involved. The supply functions were accepted as providing a given setting within which a work measurement need and applications exist.

In order to establish a perspective and a broader understanding, some discussion of work measurement in general government and industry was included. Implications of labor unions' attitudes were omitted. Human behavior factors were discussed to the extent that they are considered relevant in government type work measurement applications.

Method of the Study

Research for this paper consisted primarily of library research supported by some on-site collection of data. The library research was used to reveal historical information and provide factual data on work measurement methods and timing techniques. Current information concerning work measurement applications was obtained within the Navy Department and the Defense Supply Agency from written policies, directives, instructions, operating manuals, and personal interviews. Considerable information concerning the three work measurement systems discussed in this paper was drawn from the personal experience of the writer gained from being associated with the administration and operation of the systems.

Organization of the Remainder of the Thesis

In order to develop a foundation for projecting a fully integrated work measurement system, a logical examination and discussion of the basic concepts and elements required of the system must be accomplished. Chapter II sets the stage for the study by providing the definition, philosophy and objectives of work measurement and a look at the current efforts in industry. A brief historical picture of work measurement in government, and more narrowly the Navy, is developed along with current trends including effects of data automation.

Chapter III looks at the techniques of work measurement including the kinds of work standards and the major methods used to develop engineered performance standards. Advantages and limitations of the several techniques are discussed.

Chapter IV discusses the criteria for installing work measurement and then examines the three systems currently being applied to the Navy supply functions. An analysis of the systems in relation to each other is developed to identify significant differences and to point out apparent overlap or duplication.

Chapter V presents an outline of a fully integrated work measurement system for supply type functions. The development of the projected system is based on the facts identified and the material developed in the preceding chapters. Expression of the concepts and elements of the projected system are necessarily inclusive of the opinions of the author as they have evolved from personal experience.

From the review of work measurement, its techniques, applications and projected development, specific conclusions are reached in Chapter VI. They are: that techniques are available to effectively measure work in Navy supply functions; that there is some duplication of work measurement and reporting in the Navy supply functions; and, that a fully integrated work measurement system can be developed utilizing existing work measurement applications.

CHAPTER II

WHY WORK MEASUREMENT

Objectives of Work Measurement

Historically, work measurement has been most aggressively used in private industry for obtaining increased efficiency and productivity in factories through time standards based wage incentive programs. At this stage in the history of work measurement most organizations, both private and governmental, employ some form of work measurement to a greater or lesser extent. A representative of industry recently stated:

> A work measurement program merely supplying standards for incentive purposes, no matter how sophisticated or economical the method of standards development, should still be considered a program in its early stages.[1]

Although wage incentive programs are not widely employed in the government, many work measurement applications are found. A growing trend to expand the use of work measurement is being experienced in government. Today new management programs are demonstrating clearly that the four fundamental considerations of "men," "money," "machines" and "material" apply in government as

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[1]Joseph P. Marenghi, "Why Work Measurement," Proceedings of 14th Annual MTM Conference (New York, N. Y., October, 1966), p. 20.

well as in private enterprise. A government organization has the same problems arising from complexity and size as experienced in business.

In our free society the government expects continuing scrutiny and criticism of its efficiency. As summarized by President Kennedy in a speech to Congress:

> The search for greater efficiency is never finished. . . . What was efficient practice a few years ago may be obsolete today. . . . In striving for greater efficiency we are pressing forward on three fronts: management improvement, cost reduction, and the reform of our public salary system.[1]

Further, the President told Congress he had directed agency heads to improve manpower controls and increase productivity. He said an inspection system would be carried on to "measure the effectiveness and results of our efforts and to help uncover new ways to economize. . . . We shall maintain pressure on each agency to improve its productivity and efficiency.[1]

In order to achieve efficiency, improve productivity, and provide manpower controls, improved work measurement programs have been instituted in the government. In the Navy supply functions, as will be seen in later chapters, various work measurement systems and manpower control techniques are being employed to achieve the goals outlined above. Efforts are continuing to

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[1]U. S., President, 1961-1963 (Kennedy), Budget Message to Congress, The Congressional Record, January 17, 1963.

improve and expand coverage of work measurement to keep pace with changing systems, organizations, technology, and the needs of management.

Definition of Work Measurement

In a narrow and probably more technical sense, work measurement may be defined as: "A method for establishing an equitable relationship between the volume of work performed and the manpower utilized in completing that volume."[1] However, this definition is not considered adequate to express the full significance of "work measurement," or to put it another way, "the measurement of work." In attempting to define work measurement more completely, the aim of work measurement provides another approach.

> Work measurement offers one of the most reliable avenues or aids used by Scientific Management to achieve the benefits of increased production at lower cost for the advantage of everyone. The aim of work measurement is thus to aid scientific management.[2]

Scientific management can be broken down into its two concepts and defined thusly:

> The Scientific Method is generally understood to mean the application in a systematic manner of expert knowledge and skill.

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[1]U. S., Department of the Navy, Manual for the Integrated Work Measurement Program, NAVEXOS, p-816 (Washington: Office of the Management Engineer, Navy Department, 1950), p. 17.

[2]Delmar W. Karger and Franklin H. Bayha, Engineered Work Measurement (New York: The Industrial Press, 1966), p. 10.

> Management is the art of controlling and/or directing human activity to specific goals.
> Scientific Management, therefore, consists of directing human activity toward specific goals with maximum reliance on expert knowledge in a systematic way.[1]

With this interpretation of the aim of work measurement, a broader definition may be presented; one that will be used in this paper when referring to a "system" application rather than a kind of measurement. In the broad sense then, work measurement will be defined as an approach, a system, or a program employed to <u>improve</u>, <u>measure</u>, and <u>control</u> manpower utilization and efficiency through the application (in varying degrees) of scientific method study, methods measurement and management reporting.

Philosophy of Work Measurement

In everyday life, the importance of "yardsticks" or "bench marks" to gauge results or establish dimensions and norms is well recognized. William H. Brush, in Lazzaro's *System and Procedures*, provides a good analogy:

> The woodsman pacing off distance along a tract and the atomic physicist employing delicate and complex calculation to identify rare elements are both exhibiting the practical need to know how much. Whether the yardsticks are crude, as the woodsman's, or refined, as the physicist's, their ultimate purpose is a quantitative expression of "how much" that is meaningful, objective, consistent, and verifiable.[2]

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[1] *Ibid.*

[2] William H. Brush, "Work Measurement," *Systems and Procedures--Handbook for Business and Industry*, ed., Victor Lazzaro (Englewood Cliffs, N. J.: Prentice Hall, Inc., 1959), p. 149.

Work measurement provides a measure that is a quantitative expression of "how much" and also meets the criteria of being meaningful, objective, consistent, and verifiable. Under work measurement, subjective judgment is reduced and more objective and practical "yardsticks" of performance are provided.

Purpose of Work Measurement

Generally, any work measurement program in the Federal government can be identified with three broad major purposes. One particular program (or system) may tend to emphasize one purpose over the others; however, any well designed and applied system will provide the capability to achieve the following purposes.

1. Management Control.--Management control is that phase of business administration which examines results to determine whether, and how well, work assigned has been carried out in accordance with preconceived plans and policies.[1] Control provides management with information necessary to make plans and operations more effective. Performance effectiveness reported through work measurement is a means whereby management may exercise control. Effectiveness in work measurement is determined by relating the number of man-hours actually required to perform the work to the number that should have been required according to the work standards. Work measurement provides management with the

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[1]U. S., Department of the Navy, Manual for the Integrated Work Measurement Program, op. cit., p. 12.

information that something needs to be done, discloses where the problem lies and further provides some of the facts upon which corrective actions can be taken.

2. Management Planning.--Management planning is that phase of administration which determines when, where, how and by whom the work of an organization is to be performed.[1] To plan properly, planners must know what work is to be done, the best methods of doing it, the capacities of the personnel required, and the time required to complete the work. The more factual data available to the planners, the better will be the final plan. Work measurement provides factual data useful to planners, chiefly performance standards that may be used to gauge personnel and time requirements.

3. Budget Formulation, Justification and Control.--Work measurement provides essential data for the budgeting process including man-hours, work units, and performance rates. Workload data and the time required for its performance provide firm facts to justify personnel requirements.[2]

Work Measurement in Private Industry

As was previously indicated, work measurement in industry is most notably related to wage payment programs based on work

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[1]*Ibid*., p. 15.

[2]*Ibid*., p. 16.

standards. This application dates back to the days of F. W. Taylor with the intervening years providing little change in the basic incentive concept and considerable change in measurement techniques and management approach. The work standard today, however, is used for more than just wage plans--it is a yardstick that management uses for planning and control, and by comparison of labor content, provides information for better cost and profit decisions. The following list was taken from the Industrial Engineering Handbook and is illustrative of manufacturing oriented uses.

1. Choice of alternate methods.
2. Design of product for manufacturing method using less labor.
3. Design of productive equipment which uses less operator time or skill.
4. Selection of equipment requiring least labor.
5. Process and operation planning.
6. Design, tools, and jigs and fixtures.
7. Production scheduling.
8. Plant layout and materials handling.
9. Budgeting and cost controls.
10. Setting sales prices.
11. Manpower planning.
12. Employee relations.
13. Job evaluation.
14. Wage incentive.
15. Methods improvement.[1]

The spread of work measurement and work measurement techniques to areas outside of manufacturing has been growing since World War II. The reasons for this may be best identified by the following quotations:

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[1]J. Wayne Deegan, "Uses of Time Standards," Industrial Engineering Handbook, ed. H. B. Manyard (New York: McGraw Hill Book Co., 1956), p. 3-227.

Outstanding among the major trends during the 1950's was the much faster growth of white-collar (professional, managerial, clerical, and sales) than manual (craftsmen, operatives, and laborers) occupations, making 1960 the first decennial census in which white-collar workers outnumbered manual workers.[1]

The last decade has seen not only progress for banks, but also a progression of increased labor costs, increased competition and increased difficulty in raising the prices for their scores of services. Each organization therefore has the need for not only controlling costs but also the need for eliminating waste and increasing productivity. Many paths are available to management in accomplishing these objectives. One of these paths is work measurement.[2]

The rapid growth of work measurement in office and clerical areas of private industry can be attributed, then, to an increasing proportion of the labor force in these areas and increasing competition and costs that require management to seek ways of increasing productivity and decreasing unnecessary costs. Work measurement techniques, developed and proven in the factories, are increasingly being tested and utilized in white-collar areas. Successful applications are also being made in such areas as plant maintenance, automotive and aircraft overhaul and maintenance, and materials distribution.

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[1]Max Rutzeck and Sol Swerdloff, "The Occupational Structure of U. S. Employment, 1940-60," Monthly Labor Review, November, 1962, p. 1209.

[2]John B. Stoya, "The Installation of a Work Measurement Program," Proceedings of 14th Annual MTM Conference (New York, N. Y., October, 1966), p. 60.

Work Measurement in Government

Some form of work measurement must indeed be traceable back to the earlier days of this country and at least to the turn of the nineteenth century. However, it is beyond the scope of this paper to delve into this earlier period and thus this document will commence with what appears to be the major origin of modern work measurement--the "performance" budget.

> A performance budget--itself a report and a prediction of measured accomplishment in an organization's activities--must be based on some kind of measurement applied to the operations within those activities.[1]

Professor Burkhead indicates that: "Performance budgeting can be most appropriately associated with a budget classification that emphasizes the things which government does, rather than the things which government buys."[2] Performance budgeting places the emphasis on accomplishment itself rather than the means of accomplishment.

The growth of performance budgeting in the Federal government was minimal until the post World War II period. There was a hint at performance budgeting as early as 1912 when the Taft Commission on Economy and Efficiency stressed the importance of budgeting in accordance with the subjects of work to be done.

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[1]U. S., Executive Office of the President, Bureau of the Budget, A Work Measurement System (Washington: U. S. Government Printing Office, March, 1950), p. 1.

[2]Jesse Burkhead, Governmental Budgeting (New York: John Wiley and Sons, Inc., 1956), p. 133.

During the 1930's the U. S. Department of Agriculture and the Tennessee Valley Authority established schedules and budget classifications in accordance with programs and accomplishment. After the war the Navy Department increased the impetus to performance budgeting by developing and presenting its fiscal year 1948 budget on the traditional object basis and on a program basis. During this same period the Bureau of the Budget, the General Accounting Office, and the Treasury Department were developing the first steps in a basic improvement of accounting and budget procedures in the government. The first Hoover Commission carried the development of performance budgeting further and recommended that: "The whole budgeting concept of the Federal Government should be refashioned by the adoption of a budget based on functions, activities, and projects: this we designate a 'performance budget.'"[1]

In 1949, the National Security Act advanced the cause of performance budgeting by requiring that Department of Defense budgets be essentially performance based, and established the comptrollers in the Office of the Secretary of Defense and the military services to improve budget and accounting functions. The further significance of this act is that by passing the act, Congress expressed its approval of performance budgeting.

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[1]*Ibid*., p. 135.

With the enactment of the Budget and Accounting Procedures Act of 1950, the President was given the authority to develop and arrange the budget in a manner that would encourage the extension of performance budgeting in the Federal government. As a result, the 1950's saw a tremendous increase in performance budgeting in the Federal government and the concurrent development and installation of work measurement systems.

The Hoover Commission in its report on the Executive Branch of the government recommended, among other things, that a sustained program of management improvement be established by all federal agencies. Implicit in such a management improvement program was the need for adopting a sounder basis of budget and personnel justification derived from the knowledge of workload requirements.

The Bureau of the Budget issued Circular A-11 early in 1950 which provided instructions for submitting budget estimates and for reporting workload and personnel data for certain administrative services which were common to most federal agencies in order that broad staffing guides could be established for these services for use in budget appraisal.[1] Based on these actions by higher authority, federal agencies and departments reviewed their existing work measurement programs or requirements and took action to improve and develop work measurement systems that are today

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[1]U. S., Department of the Navy, Manual for the Integrated Work Measurement Program, op. cit., p. III.

providing information for a multitude of management purposes, among which budget formulation is basic.

The growth and development of work measurement in Navy supply functions has paralleled the general growth in the government. However, it is interesting to note that the Naval Supply Systems Command (NAVSUP) recognized during World War II that it was virtually impossible for activities to determine how effectively their operations were being performed. Shortly after the war the command (then the Bureau of Supplies and Accounts) moved to effect a program by which each activity could evaluate its own performance. The "Performance Evaluation Program," (PEP) as it was called, had as its immediate goal to strike a balance between workload and personnel. Its ultimate objective was related to budgetary deficiencies and control.[1]

Field activities and bureaus cooperated in several refinements that gave the PEP stature, and the Supply Systems Command preeminence, among Navy Department bureaus engaged in similar endeavor. In 1951, as the Performance Budget took hold and embraced the concepts of work measurement, PEP was succeeded by what is now referred to as the NAVSUP Work Measurement Program. Its original stated objectives were "to rate current operating practices and to obtain better methods, to eliminate unnecessary personnel, and to obtain a higher degree of effectiveness in terms

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[1]Rear Admiral W. J. Carter, SC, USN, Introduction to NAVSANDA Publication No. 61, 10 August 1945.

of man-hours expended for the work produced."[1] Changes in the program have been, by and large, of a refinement nature having to do mostly with work units and functional definitions. Since 1953 the focal point of the program has been the emphasis on the relationship between staffing and workload and the budget process. Chapter IV of this paper provides a more detailed description of the current program.

Current Trends in Work Measurement

The phenomenal growth in automatic data processing and the ever increasing role of the computer in management and management technology are so all encompassing and profound that change--change in management philosophy, change in management systems, change in organization--is almost the order of the day. Thomas Whisler, in his article "The Manager and the Computer" states rather vividly:

> While factory automation has already generated some large-scale problems of change, we haven't really begun to feel the full impact of the new discoveries in computer technology and management science. The problems coming up will be concentrated at the managerial level. They will evolve from changes induced in organizations by the combination of computers and management science--by information technology. They are the problems of the 1960's and 1970's.[2]

Work measurement and work measurement systems provide management with information--information used in planning,

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[1] U. S., Department of the Navy, Bureau of Supplies and Accounts, Integrated Work Measurement Program for Supply (Washington: NAVSANDA Publication No. 61, June, 1951), p. 1.

[2] Thomas L. Whisler, "The Manager and the Computer," The Journal of Accountancy (January, 1965), pp. 27-32.

performance evaluation, and control. As the technology of information changes under computer applications, work measurement and work measurement systems most certainly will be reappraised and modified accordingly. Leavitt and Whisler indicate the impact on planning and performance caused by changing information technology. They state in their article, "Management in the 1980's":

> Information technology should move the boundary between planning and performance upward. Just as planning was taken from the hourly worker and given to the industrial engineer, we now expect it to be taken from a number of middle managers and given to as yet largely nonexistent specialists: "operations researchers," perhaps, or "organizational analysts." Jobs at today's middle-management level will become highly structured. Much more of the work will be programed, i.e., covered by sets of operating rules governing the day-to-day decisions that are made.[1]

Workload and manpower data (as provided by work measurement) are fundamental imputs into money decision making functions of management, i.e., manpower utilization and control, budgeting, etc. John Diebold indicates that there will be much more emphasis on data utilization for better decision making:

> Today an ability to make correct decisions most of the time on the basis of inadequate information is a mark of the good manager, even on the middle management level. In the future, the good middle management executive will be distinguished by his ability to utilize all the data before making a decision, and then to make a decision in accordance with the dictates of the data.[2]

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[1]Harold J. Leavitt and Thomas L. Whisler, "Management in the 1980's," Harvard Business Review, XXXVI, No. 6 (November-December, 1958), pp. 41-48.

[2]John Diebold, "John Diebold Answers Twenty Questions," Automatic Data Processing, March 1959.

Just how much work measurement is required, how it is accomplished, and what necessary information is provided for decision making depends on and will increasingly depend on the computer based systems and their effect on what work is performed, who performs the work, and how the work is performed.

Atypical of recent efforts to develop new approaches to work measurement in consideration of the computer environment is the Resource Allocation and Control Technique (REACT). REACT is a special application of linear programming for manpower control and is designed to give management the leverage and perspective it needs for the control of manpower in administrative and technical areas.[1] This measurement and control approach recognizes the impact of the computer on what work is being done and who is doing it in the white-collar areas. As more and more clerical work is automated, the remaining tasks and the new tasks created by computers require higher skill levels; those of an administrative and technical nature. These tasks are difficult to measure and control with conventional work measurement techniques. The computer has facilitated the use of linear programming and the efficient handling of data associated with its application to manpower control.

Essentially, REACT is a manpower control system designed for activities that require more precise methods for planning,

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[1]William G. Bruner, "REACT for Precise Manpower Control," Financial Executive, July, 1967, p. 10.

scheduling, and controlling work.[1] The system is computer-based and correlates workforce with workload by comparing manhour, skill, and cost inputs with the work outputs produced by a group of people.

The program describes the distribution of workload in terms of employee skills and matches the work to be done with the manpower resources available. Although REACT is not based on work measurement as such, workload is allocated and performance is measured using a type of standard or target. Engineered time standards are not used. Reporting of time and production are required.

Work assignments are made by the computer using updated cost, performance, and backlog data. REACT reports measure accomplishment in terms of schedule, manpower utilization, and cost performance on each of the tasks, activities, or units completed by the employees.[2]

Among the several unique features which are claimed to make REACT superior to other types of control are: group oriented study of operations prior to installation; standards are not fixed, but vary with performance and with worker assignment; performance reports are based on actual conditions, rather than ideal circumstances yet to be realized; supervisors and employees are motivated to improve performance in small progressive steps, and

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[1] Ibid., p. 15.

[2] Ibid.

the computerized program minimizes manual handling of data and has built-in flexibility for imput/output changes.[1]

As data automation and the computer continue to impact constant change in management and management information systems, new approaches to measuring and controlling work, such as REACT, will undoubtedly be the major trend in work measurement development.

Summary

The preceding pages have identified the basic objectives of work measurement common and peculiar to both industry and government; a definition of work measurement related to its use as a system; and, a philosophy of work measurement based on the underlying practical need of knowing "how much."

Work measurement generally serves three broad major purposes. Management control and budget formulation, justification and control are the two most significant uses. Management planning can be well served by a work measurement system where time standards and workload information are used to determine personnel and work scheduling requirements.

Work measurement in private industry has been associated primarily with production line job standards and wage incentive programs. In recent years the use of work measurement has spread to areas outside of manufacturing to the office and clerical areas

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[1] *Ibid.*, p. 16.

of all types of business firms. Increasing labor costs and proportion of the labor force in white-collar areas have prompted management to employ work measurement as a means of increasing productivity and decreasing costs.

The growth of work measurement in the Federal government is attributed primarily to the concept of performance budgeting. Since World War II the emphasis on work measurement has paralleled the Executive Branch's emphasis on improved budgeting and increased efficiency in government operations. The Navy Department, particularly the Supply Systems Command, was a leader in the early development and application of work measurement for budget and manpower control purposes.

Current trends in work measurement are greatly affected, as are all other management systems, by the growth in automatic data processing and the changes constantly occurring in information technology caused by computer applications. Work measurement techniques and systems are being reexamined in light of computer technology. Questions concerning what work to measure and how best to measure it need to be answered. One approach to work measurement in the administrative and technical areas has been to use the computer to help solve measurement problems. Computer-based manpower control systems, such as REACT, are in existence today.

CHAPTER III

WORK MEASUREMENT TECHNIQUES

Generally speaking, there are two kinds of work measurement--first, the traditional industrial engineering kind where performance standards are determined by time study or other engineering measurement techniques; and second, the statistical kind where "yardsticks" are developed from a statistical analysis of past performance data.

The essential difference between the two kinds of work measurement is that in the industrial engineering kind, performance time standards are established from an analysis and timing of individual and selected operations, whereas the statistical standards are established for performance based upon the experience of groups of people doing a certain kind of work for a given period of time. The latter measure is of a broader character than that provided by the engineered performance standards. Both types of work measurement have their place in the application of work measurement systems.

This chapter is devoted to defining the major terminology found in work measurement and to examine in appropriate detail the major time measurement techniques associated with the engineered approach to work measurement.

Work Count

The work count is the foundation for work measurement application.[1] In fact, it is a form of measurement in itself. Knowledge of the number of work units produced in a given time period provides the basis for comparing the production of one period with another.

The key factor in any work count application is, of course, the work unit being counted. A work unit is generally expressed in terms of the physical items produced, and is selected as the most practical unit of production or accomplishment at the level (usually either organizational or functional) at which the work is physically performed.

The following criteria for selecting valid work units for measurement purposes are generally regarded to be the most significant.[2]

1. The work unit must be countable; i.e., expressed in quantitative terms such as line items, containers, etc.
2. The work unit must express output; that is, volume of work completed, such as line items processed or containers packed.
3. The work unit must reflect work effort. The work unit which measures the results of work performed may not necessarily measure the effort expended in performing that work. For example, results of processing requisitions may be in terms of line items issued, whereas work effort might be measured in terms of requisitions processed; for if a large number of requisitions do not result in issues there may be considerable difference between line items issued and requisitions processed.

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[1]Brush, op. cit., p. 150.

[2]U. S., Department of the Navy, Manual for the Integrated Work Measurement Program, op. cit., pp. 35-36.

4. The work unit must have consistency; i.e., the unit must have the same meaning throughout the organization and from one period to another. Similar work must be measured in the same work units by the same methods of counting and reporting.

5. The work unit must be expressed in familiar terminology; familiar to those who report, compile and use the data.

Time Unit

A working day, in measurement terms, is ordinarily divided into "productive" and "nonproductive" time. Productive time is: "That time during which an employee is in a work status"; i.e., "the time spent in actually performing work chargeable to an operation, including time worked in excess of the normal working day, together with appropriate rest periods, and necessary stand-by time chargeable to the operation."[1] Nonproductive time is defined as: "All periods out of the work day that an employee spends away from his work station, including time on paid or unpaid leave, or in special training."[2]

A time unit selected should apply to all hours of productive and non-productive time so that all of an employee's time may be accounted for and properly related to the unit of output. The time unit selected should be:[3]

(1) Easily recorded and reported.
(2) Capable of verification by official time or attendance records.
(3) An accurate reflection of actual time spent in the performance of work.

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[1] BuBud, A Work Measurement System, op. cit., p. 17.

[2] Ibid.

[3] U. S., Department of the Navy, Manual for the Integrated Work Measurement Program, op. cit., p. 38.

(4) Comparable over a period of time.
(5) A suitable means to distinguish among the different types of work in which time is spent.

The man-hour is the most common time unit used in work measurement. The man-hour is a unit by which employees can record their time on a continuous basis with reasonable precision and a minimum of paper work.[1]

Work Standards

In the broadest sense a standard may be defined as a method, means or procedure to be used as a guide or model for carrying out a specific type of task.[2] Defined in this way, a standard is a set of instructions, or specifications, for the performance of a given task. A work standard is more properly a measure of accomplishment that should be attained in a specified activity under specified methods and conditions affecting the activity.[3] The primary purpose of a work standard is to provide a basis for evaluating performance against a benchmark. A work standard is normally expressed in time allowed per work unit. In some cases, where the standards are group-based, the standard is expressed in terms of number of work-units to be accomplished in an allowed amount of time--i.e., a production rate. Work standards can be classified under three general kinds. They are:

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[1] Ibid., p. 39.

[2] Henry G. Hodges, Management Principles--Practices--Problems (Cambridge, Mass.: The Riverside Press, 1956), p. 161.

[3] Brush, op. cit., p. 153.

1. Subjective.--Simply stated, this is a rule-of-thumb type of standard based upon the experience, opinion and judgment of an individual. Normally this type of standard is established by a supervisor for his own use. Quite often production records exist which are not based on the kind of work and time units that are needed for work-measurement purposes. Such records, nevertheless, may offer quantitative information good enough to improve the subjective estimates being used as standards. Standards established by these methods can be set quickly; but that very fact is one of the main arguments against their use. There may be considerable disagreement concerning the standard's accuracy and applicability.

2. Statistical Standards.--This type of standard is developed by using past records of time and production to ascertain the average time per unit of work. The statistical work measurement standard combines sound statistical experience and analysis with the judgment of management that provides a standard more reliable than a subjective standard. The statistical method is flexible and can be applied at different levels of work in varying (but not unlimited) degrees of work standardization. This type of standard provides a fairly sound basis for comparison of performance and guidance for improving this performance. Because the unit times are based on historical data, the standards do not provide what the unit time "should be."

3. Engineered Standards.--This type of standard is developed through extensive detailed analysis and precision measurement using an engineered time measurement technique. Engineered standards involve both methods and time analysis and are time-consuming to establish and maintain. An engineered time standard may be more completely defined as: The amount of time required to perform a given task, following a prescribed method, by an individual possessing average skill and exerting average effort, under normal conditions. The remainder of this chapter is devoted to the examination of the major measurement techniques used in developing this kind of a standard.

Methods and Time Study

Definition and Background

Methods and time study is that branch of knowledge dealing with the scientific determination of preferable work methods, the appraisal, in terms of time, of the value of work involving human activity, and the development of material required to make practical use of these data.[1]

The first book on time study in the United States was written in 1920 by Dwight V. Merrick, a time study man who worked

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[1]Marvin E. Mundel, Motion and Time Study--Principles and Practice (New York: Prentice-Hall, Inc., 1950), p. 1.

with F. W. Taylor, the so-called "Father of Scientific Management."[1] First known simply as "time study," the procedure later added "motion study." As the study of operator motions was expanded to include the machine, materials, workplace, and the general working environment, the technique came to be known as "methods and time study."

Although time studies were made in France and England prior to 1920, Taylor's time study work at the Midvale Steel Company, starting in 1881, developed more detail by breaking down operations into elements.[2] An element in time study is the smallest number of motions that can be practically isolated, and for which dependable elapsed times can be determined. Frank B. Gilbreth and his wife subsequently developed many of the improved techniques used in the study of motions which are common to the elements of machine and assembly-operator operations.

The methods study phase may be more completely defined as a procedure for scientific analysis of work methods, considering (a) the materials used in the product, (b) the design of the product, (c) the process or order of work, (d) the tools, workplace, and equipment used in the process, and (e) the hand and body motions used in each step of the process in order to determine a preferable work method. It has long been recognized that there

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[1]Hodges, <u>op. cit</u>., p. 328.

[2]<u>Ibid</u>.

is no one "best" method for performing a given task. However, through the use of scientific method study procedures, improvement can be made in the five factors mentioned above and can result in the overall achievement of "better" or preferred methods. The criterion of preference is usually economy of money, but ease or economy of human effort, economy of time, or economy of material frequently may take precedence.[1]

The time study phase may be defined as "a procedure for determining the amount of time required, under certain standard conditions of measurement, for tasks involving some human activity."[2] It is difficult to separate completely the two phases--methods study and time study. Each complements the other. The methods study, while establishing a preferred method, provides a detailed description of the job usually in the form of a written standard practice, a necessary requirement for an elemental time study.[3] Also, time measurements are often a part of the basis upon which alternative methods are compared.

Motion and time study can be considered as a measurement technique involving three phases of activity: method determination, time appraisal, and development of data for application. The application of the data, for work measurement purposes, is usually development of the time study data into a time standard expressive of the allowed time to perform a specific task or to accomplish a

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[1]Mundel, op. cit., p. 1.

[2]Ibid.

[3]Ibid.

single unit of output.

Time Study Procedure

The most common type of time study, using a stop watch, generally consists of the following major steps. First, the job is studied for methods improvement and the resulting preferred methods are taught to the operator. Second, the various elements to be timed are identified and sufficient stop watch readings of each are recorded by observing a qualified operator to obtain statistically valid average performance times for each element. Third, the time study analyst must, while conducting the time study, observe and judge the skill and effort levels of the operators performing the task. Performance rating is required since valid time standards rely on finding the time for an average operator employing a consistent method with average skill and effort under average conditions. Any particular operator being studied may vary from this norm. His actual performance time must be adjusted if the time is to be used in the development of a standard meeting the above requirements. Such adjusted actual times are referred to as "leveled" times. In most time studies each individual element is "leveled" based on the performance rating procedure.

There are two major methods of stop watch timing. The repetitive or snap-back method consists of timing each element by starting the stop watch at zero reading at the beginning of each element. In order to do this the stop watch is reset to zero at the end of each element. This method limits the amount of arithmetic computation by providing element times directly; however, some inaccuracies may result in using this method. Mental lag and slowness in snapping the watch back to zero can introduce errors in timing that will result in inaccurate final times.

The continuous method of timing requires that the stop watch remain running the duration of an entire study, the elemental readings being made as the watch moves and wherever the hands happen to be as each element is completed. Elemental times are recorded in sequence as they occur while the watch is running. In order to do this accurately the analyst must be familiar with each element description and its start and stop point. This method gives a series of readings, each of which must be subtracted from the preceding reading in order to obtain the elapsed elemental time. The continuous method requires concentration and mental agility in order to observe the exact time when elements are completed and record the time. Among most time study analysts, the continuous method of timing is believed to give the most valid time data.[1] This method accounts for every minute of the time study; it minimizes the danger of omitting elements; and it eliminates inaccuracies caused by the watch manipulations required in the snap-back method.

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[1] Brush, op. cit., p. 162.

One of the chief advantages of the continuous method over the repetitive method of stop watch study is that it is quite easy to rationalize the study with the operator if he has any questions to raise after it is completed.[1] If the exact clock starting time of the time study is recorded on the time study sheet as well as the clock time at the completion of the study then the total elapsed time can be compared to the total stop watch time to determine whether the stop watch reading is approximately correct. This comparison to total elapsed time often serves to alleviate the fears of the operator concerning foreign elements, short cycles, out of sequence elements, and missed readings. The examination of these two most popular methods (there are others such as accumulative timing and cycle timing) serves to illustrate the need for accuracy in use of the stop watch and ability on the part of the analyst in employing the time study approach to measuring work.

After obtaining a sufficient number of element time values and adjusting these times for average performance, certain additions of time must be made before a final time standard can be established. Such time or percentage adjustments are referred to as allowances.[2] One additive includes those necessary steps or parts of the total job that were not directly measured by the time study. Illustrative of this type of allowance are, for example:

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[1]Delmar W. Karger and Franklin H. Bayha, Engineered Work Measurement (New York: The Industrial Press, 1966), p. 473.

[2]Ibid., p. 519.

2. Time study is a technique more universally recognized and understood by all concerned parties.[1]

3. Time study provides a reliable and accepted technique for the following major purposes:

a. Establishing time standards for incentive wages and for performance evaluation.

b. Establishing time standards for determining the number of workers necessary to accomplish a given workload.

c. Establishing time standards for use in scheduling and controlling work through an organization or process.

d. Evaluating methods improvement proposals through comparison of time data developed for each proposal based on time studies.

Disadvantages of Time Study

The most referred to, and probably most significant disadvantage of the time study procedure is the role of judgment in determining the final allowed time. The process of timing an operation with a stop watch is quite mechanical when being accomplished by a trained and experienced analyst. The rating of the operator's performance--e.g., skill and effort--during the operation is a pure judgment process on the part of the time study analyst. Although training and experience help in this area too, because it is human judgment that must be relied upon, the entire time study procedure is subject to question and criticism. The

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[1] Ibid.

criticism does not stem solely from the fact that judgment is used in this "scientific approach to work measurement," for a great deal depends on the investigator's judgment even in sciences as esteemed as physics. However, the critics point out, rules of experimental inference demand that estimating procedures be independent of the observer.[1] Worker performance rating in time study is, of course, accomplished by the analyst recording the element times. Although standard rating criteria have been developed and accepted by most in the time study field, it appears that the performance judgment step in the time study technique has marked the entire process with an "error rate" factor higher than it probably deserves.

Predetermined Time Systems

The use of predetermined time systems in the measurement of work provides another technique for the development of engineered performance standards. Professor Delmar Karger in his Engineered Work Measurement offers the following definition of predetermined time systems.[2]

> A predetermined time system is an organized body of information, procedures, and techniques employed in the study and evaluation of work elements performed by human power in terms of the method or motions used, their general and specific nature, the conditions under which they occur, and the application of prestandardized or predetermined times which their performance requires.

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[1]Adam Abruzzi, Work, Workers and Work Measurement (Morningside Heights, New York: Columbia University Press, 1956), p. 26.

[2]Karger and Bayha, op. cit., p. 35.

The factors of motions and elapsed times have been recognized as the major consideration in engineered work measurement since the days of Taylor and the Gilbreths. However, it has not been until rather recently that the significant relationship between the two has been fully understood and employed. It has been accepted that attention should be given to both the motions and the elapsed times involved in work performance if major benefits are to result from any form of work measurement. Today the principle is being followed in methods engineering and places the development and application of predetermined time systems on a sound scientific basis. The basic key to predetermined time systems is the fact that variations in the times required to perform the same motion are basically small for different workers who have had sufficient practice.[1]

Predetermined time systems were slow in development, with only three different systems in use during the 1930-1940 period.[2] With the shortage of material and manpower brought about by World War II, American industry was faced with the need for large increases in productivity in a relatively short period of time. Industry was forced to pay more attention to labor-saving devices and manpower/management control. From the war period on through the 1950's predetermined time systems increased in number and their application spread as competition and costs continued the need for effective manpower measurement and control. The

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[1] Ibid., p. 32.

[2] Ibid., p. 33.

application of these systems spread from the shops and factories to the office and white collar areas of the more progressive businesses and government agencies.

Major Predetermined Time Systems

Motion--Time Analysis

This system was developed in 1924 by Mr. A. B. Segur and is perpetuated by the A. B. Segur Company. It was the first known to be developed and is considered the oldest. Little is known about the system because its data are tightly controlled by the Segur Company. MTA, the abbreviation for this system, has motion categories based on physiological principles, variable times for variable motions, rules of usage, and an approach to motion combinations. The system is considered sound based on its long lifespan and utilization by many firms.[1]

Work-Factor

The Work-Factor system was developed by Joseph Quick and his associates. It was founded on accumulations of stop watch studies, plus other measurement aids, over a long period at the Radio Corporation of America. The system is the trade-mark of the Work-Factor Company which provides the system with consultant services. Work-Factor has several sets of data. Each is designed to provide a degree of accuracy based on management needs and the given situation.

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[1] *Ibid.*, p. 40.

Work-Factor recognizes motion variables including weight, distance, degree of control, and the acting body member. The distance and body member variables are handled directly through time table headings, while the effect of weight and degree of control are handled by a more involved approach. A variable number of work-factors is assigned to a motion involving weight or degree of control. The allowed time increases proportionately with the applicable number of work factors.

Work-Factor's success has been in the electronic industry and in other industries having relatively small light load type assembly operations.[1]

Basic Motion Timestudy (BMT)

This system was developed by J. D. Woods and Gordon, Ltd., a Canadian consulting engineering firm. The system is basically a revised set of data found in the Methods-Time Measurement (MTM) predetermined time system.[2] BMT also includes features of several other predetermined time systems. Information published in 1956 by Ralph Presgrave, one of the system's developers, indicates that considerable additional research went into the development of the BMT system. One unique feature of BMT, Presgrave points out, is the definition of a "basic motion." BMT includes in the definition of a basic motion all motion of a body member that has been at

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[1] *Ibid.*, p. 41.

[2] *Ibid.*, p. 43.

rest, moves, and again comes to rest.[1] This concept of a basic motion differs from that of Methods-Time Measurement. Other minor motions are considered to occur in the MTM system under the description of a "basic motion" as identified in BMT.

Methods-Time Measurement

Methods-Time Measurement is the only predetermined time system whose entire data, including the basic research, has been made available to the general public. The system was developed at the Methods Engineering Council, Pittsburgh, Pennsylvania, by Messrs. Harold B. Maynard, Gustave J. Stegemerten, and John L. Schuab. The preliminary work was done at the Westinghouse Electric Corporation in the early 1940's, with the first MTM text appearing in 1948. The official MTM definition is:

> Methods-time measurement is a procedure which analyzes any manual operation or method into the basic motions required to perform it and assigns to each motion a predetermined time standard which is determined by the nature of the motion and the conditions under which it is made.[2]

The Methods-Time Measurement system is controlled and maintained by the MTM Association for Standards and Research. This association has as its purpose to: widen acceptance for the proper use of MTM; conduct basic and applied research in the field of methods-time measurement; establish standards for high quality

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[1]Ralph Presgrave, "Standardization of Work Measurement," H. B. Maynard, ed., Industrial Engineering Handbook, p. 4-92.

[2]Harold B. Maynard, Gustave J. Stegemerten, and John L. Schuab, Methods Time Measurement (New York: McGraw Hill Book Company, Inc., 1948), p. 12.

in the use of MTM; and, to compile and provide to members current information pertaining to the development and application of Methods-Time Measurement.[1] Through the efforts of this association and because the system is available to the public, MTM is widely employed both in private industry and government on a world-wide basis.

There are many other predetermined time systems in use today. The following list identifies some of the more often mentioned systems.

General Electric

Holmes

Mundel-OPAPT

Minneapolis-Honeywell

Western Electric

Body Member Movements

Dimensional Motion Times

Elemental Time Standards

Predetermined Time Systems Procedures

In predetermined time systems, tasks are broken down into much smaller elements than in time study. Elements in time study are made up of many human motions grouped together for convenience and accuracy in timing by stop watch. Stop watches are not required when applying predetermined time systems because basic

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[1]Karger and Bayha, op. cit., p. 64.

human motions have predetermined time values established for them. Thus, when applying predetermined time systems, basic body motions such as reaches, grasps, moves of fingers, hands, arms and other body motions, as necessary, are identified and recorded. Time values are then recorded for these motions as provided in the data developed for the system. By adding the time values recorded for a given operation following a prescribed motion pattern, the total time to perform the task is determined. Most predetermined time systems have the "leveling factor" already built into the time data. This eliminates the need for performance rating on the part of the analyst at the time of system application. To the sum of the recorded times are added the usual allowance for delays, personal and fatigue factors to arrive at a final standard or allowed time.

Advantages of Predetermined Time Systems

1. Because most predetermined time systems have the "leveling factor" already built into them, the performance of the operator or operators performing a task measured by this system does not have to be rated for skill and effort. This eliminates one of the major disadvantages attributed to time study--the observer making a personal judgment of an operator's performance. The time data in these systems are adjusted to "normal performance" when they are originally developed, after extensive research and testing by experts.

2. Predetermined time systems do not necessarily require that an operator perform the task to be measured. The analyst, when fully trained and experienced in the system, can himself visualize (and perform if helpful) the motion pattern necessary to perform the task and can record those motions away from the actual work site.

3. Working with the basic motion pattern of a task, the analyst can improve the operation as he develops the job time. He can visualize and test alternate methods and motion patterns to arrive at the most economical method.

4. Operator training is not required on a new task prior to development of a job standard using a predetermined time system.

Disadvantages of Predetermined Time Systems

1. Although predetermined time systems are easy to understand in theory and have complete time data already available, they require considerable training and experience on the part of the analyst before speed and accuracy of application can be expected. Many systems have finite and complicated motions and motion patterns that are difficult to observe or visualize without the proper training and experience. Confidence on the analyst's part is important and is related to the complexity of the system and his experience with it. For this reason many analysts revert to time study in situations when a predetermined time system may be more appropriate.

2. The great detail of motions and time data found in most systems makes the application of these systems, even when employed by experienced analysts, more time-consuming than stop watch studies. This is especially true in operations where task cycles are relatively long and involve a variety of motion patterns. The determination of which technique to use, time study or a predetermined time system, often rests with this consideration. Other factors, however, must be considered that make the choice of techniques more difficult.

Work Sampling

One of the more promising tools with which the methods engineer has to improve his results, principally in the areas of indirect standards and determining allowances without using all-day time studies, is known as Work Sampling. A.S.M.E. Standard 106 entitled "Industrial Engineering Terminology" defines work sampling as "a statistical sampling technique employed to determine the proportion of delays or other classifications of activity present in the total work cycle."

Work sampling was originally introduced in Great Britain by L. H. C. Tippett in studies of textile industry machines and operators. The technique of measurement was referred to as ratio-delay because its initial use was to measure the percentage of time a machine or man was either working or idle. Work sampling was first used in the United States in 1940.[1] This method of work

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[1]Ralph M. Barnes, Motion and Time Study (New York: John Wiley and Sons, Inc., 1963), p. 517.

measurement is becoming more and more popular because of its simplicity and broad coverage in less time than either time study or predetermined time systems.

Work Sampling Procedure

In essence, the work sampling procedure relies on statistical concepts related to probability theory (as in statistical quality control) to reduce the amount of work (number of readings or sample size) required to obtain an average value for a measurable unit to a specified degree of accuracy for the element or elements being measured. Information regarding happenings during a whole period of time can be predicted within known limits of mathematical validity by taking the proper number of random samples throughout the entire period of time. The work sampling procedure can be used to develop, with only a limited number of observations, such things as a percentage delay due to one or more causes and frequency of occurrence of irregular elements. Sampling procedures are used in time study and predetermined time systems to develop allowance percentages for walking, talking, etc.

Work sampling procedures can also be used to develop performance times for labor standards. By observing and recording, during the sampling process, various productive tasks and maintaining associated work counts for these tasks, a time can be established for performing each task. If the observer rates the performance of the operators during the study period for skill and effort, a performance standard similar to time study standards can be established.

To overcome the problem of rating the performance of the operators an approach is sometimes used combining predetermined time systems, which already have leveled time values, and the work sampling technique. By measuring several of the major productive jobs by both the predetermined time system and work sampling, a factor is developed representing the average performance level of the group being studied. This factor is then applied to the other tasks measured solely by work sampling to adjust these times to average or normal times. Generally, work sampling for developing performance standards is limited to work that is not highly repetitive.[1]

Advantages and Disadvantages of Work Sampling

The following list of advantages and disadvantages of work sampling in comparison with time study was initially prepared by Professor Barnes.[2] The comments concerning work sampling and predetermined time systems were initially prepared by C. K. Phillips, and are shown in parentheses.[3]

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[1]Karger and Bayha, op. cit., p. 562.

[2]Barnes, op. cit., p. 532.

[3]Charles Klingelhofer Phillips, "A Survey of Standard Data--Its Evaluation, Uses, and Problems" (Unpublished Master's Thesis, College of General Studies, The George Washington University, Washington, D. C.), p. 45.

Advantages

1. Many operations or activities which are impractical or costly to measure by time study (or predetermined systems) can readily be measured by work sampling.

2. A simultaneous work sampling study of several operators or machines may be made by a single observer. Ordinarily an analyst is needed for each operator or machine when continuous time studies are made. (Continuous or group studies are not possible with predetermined time systems).

3. It usually requires fewer man hours and costs less to make a work sampling study than it does to make a continuous time study. The cost may be as little as 5 to 50% of cost of the continuous time study.

4. Observations may be taken over a period of days or weeks, thus decreasing the change of day to day or week to week variations affecting results. (This also is true of predetermined time systems if motion patterns are determined from one-time observation of operator. However, pattern should normally be checked with both operator and supervisor.)

5. There is less chance of obtaining misleading results as the operators are not under close observation for long periods of time. When a worker is observed continuously for an entire day, it is unlikely that he will follow his usual routine exactly.

6. It is not necessary to use trained time study analysts (or predetermined time system analysts) as observers for work sampling studies unless performance sampling is required. However, if a time standard or performance index is to be established, then an experienced time study analyst (or predetermined system analyst) must be used.

7. A work sampling study may be interrupted at any time without affecting results. (Same is true of predetermined systems analysis.)

8. Work sampling measurements may be made with a preassigned degree of reliability. Thus the results are more meaningful to those not conversant with the methods used in collecting the information. (Consistency is one of the advantages claimed by predetermined time systems.)

9. With work sampling the analyst makes an instantaneous observation of the operator at random intervals during the day, thus making prolonged time studies unnecessary. (Prolonged observation is unnecessary in predetermined time systems.)

Disadvantages

1. Ordinarily work sampling is not economical for studying a single operator or machine, or for studying operators or machines located over wide areas. The observer spends too great a proportion of his time walking to and from the work place or walking from one work place to another. Also, time study, elemental data, or motion-time data are preferred for establishing time standards for short cycle repetitive operations.
2. Time study permits a finer breakdown of activities (so does PTS) and delays (PTS cannot measure delays) than is possible with work sampling. Work sampling cannot provide as much detailed information as one can get from time study (or PTS).
3. The operator may change his work pattern upon sight of the observer. If this occurs, the results of such a work sampling study may be of little value.
4. A work sampling study made of a group obviously presents average results, and there is no information as to the magnitude of the individual differences. (PTS does not measure groups.)
5. Management and workers may not understand statistical work sampling as readily as they do time study (or PTS).
6. In certain kinds of work sampling studies, no record is made of the method used by the operator. Therefore, an entirely new study must be made when a method change occurs in any element.

Standard Time Data

Definition and Background

Although standard time data is classified separately as a method of measurement it is a system or really a concept that makes use of basic time data generated by other time measurement systems. Standard time data is a logical outgrowth of industrial engineering efforts to gain accurate results quickly and to use all existing information available.

Standard time data is defined in A.S.M.E. Standard 106, "Industrial Engineering Terminology" as:

> A compilation of all the elements that are used for performing a given class of work with normal element time values for each element. The data are used as a basis for determining time standards on work similar to that from which the data were determined without making actual time studies.

Standard Time Data Procedures

Standard time data is employed essentially the same as a predetermined time system. A specific task is reviewed and a preferred method is established. Then, depending on the type of standard time data being utilized, the elements or series of elements are identified, classified and assigned times from the appropriate standard time data tables. The most difficult step in the application of standard time data is determining the correct "fit" of the time data to the task being measured. All times in standard time data represent specific motion patterns categorized to reflect a standard method of accomplishment. If the motion patterns in the task being measured are not the same as in the standard data, or if task elements are different, the standard time data will not give valid results.

In developing performance standards with standard time data certain allowances must be added, as with the other basic measurement techniques, to arrive at a final job standard. The time data in standard data are preleveled times similar to those in many predetermined time systems, and performance rating of the operator is not necessary.

Standard time data may be developed for tasks that are commonly performed and repetitive using time study and/or predetermined time systems. In recent years considerable standard time data has been prepared using Methods-Time Measurement, a popular predetermined time system. The following list of published standard time data illustrates some of the areas and applications covered by this technique.

1. Master Clerical Data is a volume of standard time data for clerical and machine accounting operations covering approximately 80% of the fundamental manual paperwork tasks performed in an office. It was originally compiled and published by the Naval Supply Systems Command, Navy Department, in the late 1950's.

2. Master Packing Data is another Navy Department volume of standard time data covering the major processes associated with packing military material for shipment. It was originally published in 1963.

3. Engineered Performance Standards is a series of publications covering data used for estimating public works type maintenance and repair work. Included are such areas as carpentry, painting, plumbing, etc. The data were developed and published by the Naval Facilities Engineering Command, Navy Department, and are extensively in use at naval installations.

4. Yale and Towne Data are standard time data developed by the firm originally of that name for use with their fork lift equipment. The data have been used extensively in the Navy in developing performance standards for warehousing operations.

5. Materials Handling Standard Time Data is a volume of standard data covering military warehousing functions. The data were originally developed for the Warehousing Gross Performance Measurement System, a Department of Defense manpower measurement system. The data consist of a structured set of time data supporting the measurement system and covering such functions as receiving, issuing, packing and shipping military material. The data were officially published in March of 1967.

6. Master Standard Data and Master Clerical Data cover common paper work tasks and are compiled using MTM and a coding system that eliminates much of the reference and cataloguing problems associated with voluminous data. The data were developed and published by the Serge A. Birn Management Consulting firm.

Advantages of Standard Time Data

1. A major advantage of standard time data is that once the time-consuming effort of developing a detailed motion pattern for a common element has been accomplished, it need not again be repeated and is available in the standard data files for direct application when needed.

2. Standard time data, like predetermined time system data, can be used to develop performance standards in advance of the operation actually being performed and in the development of improved methods.

3. Standard time data when properly categorized and referenced are transferable, thereby strengthening the work measurement capabilities of organizations that cannot afford large staffs of industrial or methods engineers.

4. Maintenance of performance standards developed from standard time data is usually less time-consuming and hence less costly than other basic measurement techniques.

Disadvantages of Standard Time Data

1. The vast amount of time data developed and in use in time standards is lost for purposes of standard time data if not effectively identified (detailed motion descriptions), categorized and referenced for easy look-up. This is an expensive undertaking which is often avoided even though the time data could be employed again and again in like situations.

2. Standard time data, because of seeming simplicity of application, can be easily misapplied if not carefully checked against the operation to be timed.

3. There are important data concerning the task being measured other than the motions involved when applying standard time data. For example, the frequency of occurrence of motions or elements may be necessary to compute correct cycle times. These frequency requirements often involve detailed and time-consuming sampling or count procedures to obtain. This effort often surpasses the effort involved in applying the standard time data.

Criteria for Establishing and Applying Standards

There is no universal set of rules for determining when to establish and how best to apply work standards. As with most management tools the answer lies with management's own needs. These needs, of course, vary from organization to organization and indeed within the organization. If a work measurement system is to be installed or a present system modified, the nature of the work standard, the type of measurement technique, and the use of the system information will essentially depend on the following major factors:

1. The nature of the work (clerical, manual labor, etc.).
2. Job length (cycle time) and repetativeness.
3. Volume of work (stable, fluctuating).
4. Number of employees (the number performing the same job).
5. Permanency of jobs (life length).
6. Procedures stability (dynamic vs. static systems).
7. Organization (vertical vs. functional).
8. Budgeting system (role of work measurement).
9. Management planning and control system (manpower aspects).
10. Problems peculiar to the organization (e.g., cyclical work).

The above list is by no means complete; however, it serves to illustrate the scope of the considerations that must be given when attempting to evaluate criteria for work standards.

Summary

In this chapter work measurement was examined from the standpoint of its narrowest definition--that is, the specifics of measuring work. In measuring work there are essentially two kinds or ways--the detailed engineered measurement using industrial engineering measuring techniques and the statistical approach using historical data.

Under either kind of measurement it is necessary to identify and provide work counts, time units and work standards. A work count is a form of measurement itself and derives from work units being expressive of physical items produced or acted upon. The time unit, usually expressed in man-hours, is also a form of measurement and prevides the amount of time consumed by workers in accomplishing work. By relating these two basic measures a work standard may be developed that expresses time per work unit. The work standard is the "measurement" in work measurement.

There are three general kinds of work standards--subjective, statistical, and engineered. Each has its merits and limitations with the degree of accuracy and finiteness ranging from very little under the subjective standard to considerable under the engineered standard. The subjective standard may be considered a "judgment" measure, while the statistical standard may be identified as a measure of past performance expressed as a "did take" time per work unit. The engineered standard evolves from the detailed examination of the work to be measured and the development of time requirements based on scientific and engineered determinations. The engineered standard, then, is expressive of "should take" time per work unit. The subjective and statistical work standards are usually easy to develop and apply while the engineered standards are generally costly to develop, use, and maintain. The selection of the appropriate work standard for a given situation will depend on many factors, least of which will probably be some cost vs. required accuracy determination.

The development of engineered time standards is accomplished by employing various time measuring techniques. Time study, predetermined time systems, work sampling and standard time data are the major techniques utilized in establishing engineered time standards. Time study is the oldest and best understood method. Method study has long been associated with time study because it was early recognized that prior to establishing any valid times for operations a specific method of doing the work must be developed and prescribed. Methods study often involves a finer analysis of manual operations referred to as motion study. The concept of preceding the measurement of work with some form of methods analysis and improvement is recognized not only in time study but in other measurement techniques such as predetermined time systems and standard time data. For all measurement techniques, the methods (including motions) analysis phase provides a job or operation description and elemental breakdown that facilitates the time measurement phase. Time study's major limitation is the requirement for the time study analyst to subjectively rate the performance of the operator being timed. This personal judgment process has long been the subject of much controversy and has restricted the use of time study in many industrial situations. Time study's chief advantage is that it is, in most cases, the most economical method of establishing an engineered standard.

Both predetermined time systems and standard time data are time measurement techniques that do not require the use of a stop watch. They are systems that have time data already developed and arranged for selective application to jobs or operations based on the motions and methods involved. Predetermined time systems have time values developed and categorized according to basic motions and motion patterns common to the performance of manual operations. Standard time data systems are essentially the same only with the time data consisting of larger values and covering a whole series of motions or operation elements. In both systems, by identifying and recording motions/elements, time values can be selected from look-up tables, and when added together provide total job times. The major advantage of these techniques is that the predetermined time data are already adjusted for average performance and rating of the operator for skill and effort is not required.

Work sampling is a statistical measurement technique based on the laws of probability. The technique consists of making random observations of individual workers and their work. Its major contribution to work measurement has been to provide occurrence and duration information on job delays and portions of operations not measured by other techniques. Its major advantage is that large quantities of measurement data can be obtained by few analysts covering a work area. The technique is limited when finite measurement is required.

The selection for use of any of the techniques described is most often controlled by the nature of the work, the purpose of measurement, and the availability of trained analysts. In most cases, a successful work measurement program using engineered standards will employ more than one measurement technique and will utilize each to supplement and/or complement the others. For example: A particular operation being performed by a worker may have the more highly repetitive and shorter elements measured by a predetermined time system or standard time data, while the longer and less repetitive elements may be measured by time study. Delay allowances may be developed through work sampling. The final work standard would include the measurement results of all three (or four) techniques.

In selecting engineered measurement techniques and, for that matter, the type of work standards to be utilized in a work measurement program, several factors must be studied and evaluated.

Chief among those listed in this chapter are those dealing with change. Nothing can be more costly or disastrous to a work measurement program than the factor of change; change in work, change in workload, change in systems and procedures, to name a few. In most cases of change, particularly in systems and procedures, time standards are affected and if not invalidated they lose much of the accuracy or significance for which they were originally established. The effects of change must be examined and weighed to determine the type of standards coverage, the scope of standards coverage and the depth of standards coverage. These factors determine the measurement approach (statistical or engineered) and the measurement techniques (time study, etc.). In turn, then, both expected results and expected costs must be compared and evaluated for these factors before selecting the approach and the measurement technique.

CHAPTER IV

WORK MEASUREMENT APPLICATIONS

One of the most important problems confronting the majority of managers today is to determine how much manpower is needed to adequately accomplish assigned functions. In many instances the most embarrassing question that could be posed to a manager is: "How do you determine your manpower requirements and control manpower utilization?" Many applications of work measurement today are designed and being used for this essential task.

Criteria for Installing Work Measurement

Before embarking upon a program of work measurement there are factors that should be given some faithful attention. The following list of rules compiled by William H. Brush is not necessarily complete, but it provides an indication of the range and type of criteria to be considered.

1. First and foremost, make sure that management is sold on such plans.
2. Educate management and workers in the objectives and workings of the program. Remove the mystery.
3. Find competent people to develop and maintain the measurements.

4. Base the measurement on sound principles and practices.

5. Do not attempt to apply measurements where a practical unit of measurement cannot be found for the operation. The work count should be clearly defined and easily made.

6. Make the measurements fair to both the worker and the company.

7. Where wage incentives are applied, make the reward for extra production sufficiently attractive to interest the worker. Keep it separate from the company's base wage program.

8. Find a way to make the program simple and easily understood. A simple program is the most effective.

9. Install a good program for maintaining standards. More than one program has failed because standards were not properly adjusted when the method changes.

10. Establish a policy of not changing standards unless there is an error in the original calculation of the standard or there is a change in method. Nothing will break down a measurement plan faster than changing standards for other reasons; employees will resist arbitrary changes in standards.

11. Establish an acceptable basis for determining results of the program. A sound basis for comparing costs before and after measurement goes a long way toward establishing confidence in the plan.

12. Establish a good personnel policy for handling displaced persons. Indiscriminate layoffs or transfers will eventually wreck such a program. In many instances, normal turnover will take care of the problem.

13. Help the worker find his full potential under the program. Encourage and assist him to attain standards.

14. Finally, after a decision has been made to apply measurement in one unit of the company, have the courage to go forward with similar plans in other areas where measurements can be applied. It will pay dividends and will reassure the workers that all are being treated alike.[1]

The support of management is fundamental to the successful application of work measurement. Recently, a staff industrial engineer of Massey Ferguson Industries, Ltd. stated:

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[1]Brush, op. cit., pp. 181-183.

> . . . To gain full advantage of a work measurement program, the import should be felt in practically every facet of the organization. In all possible areas decisions based on guesswork, tradition, hunches or habit should be based on facts. All too often the facts are readily available but not put in use. A survey taken of 60 factories with established work measurement programs showed that 79% of managers or supervisors of the programs felt that the single-most important factor that restricted the scope of their work was lack of management support.[1]

In considering work measurement for control purposes additional factors should be examined. Peter Drucker, in speaking on controls (controls in general), said:

> The basic question is not "How do we control?," but "What do we measure in our control system." That we can quantify something is no reason at all for measuring it. The question is: "Is this what a manager should consider important?" "Is this what a manager's attention should be focused on?" "Is this a true statement of the basic realities of the enterprise?" "Is this the proper focus for 'control,' that is, for effective direction with maximum economy of effort?"[2]

In designing any work measurement system there are many main alternatives to choose between and there are variables in the environment that must be reckoned with. Nathan Schachter has identified and categorized these variables as follows:

> Design Variables
> 1. How much methods study before setting the standards.
> 2. Which techniques to use in setting the standards.
> 3. What kind of reports.
> 4. What type of internal audit (of the system).

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[1] Marenghi, op. cit., p. 20.

[2] Peter F. Drucker, "Controls, Control and Management," Management Controls: New Directions in Basic Research, ed. Charles P. Bonini, Robert K. Jaedicke, and Harvey M. Wagner (New York: McGraw-Hill Book Company, 1964), p. 289.

Environment Variables

1. The nature of the work to be measured.
2. The purpose to be served by the work measurement systems.
3. The caliber of the people available to develop and run the system.
4. The management climate.[1]

The extent to which all of the above factors are examined and considered will weigh heavily in the successful implementation and administration of a work measurement system.

Work Measurement Systems in Navy Supply Functions

With the material in Chapter III and the above outline of criteria serving as background, an examination of three work measurement systems currently operating in Navy Supply functions is presented in the remaining portion of this chapter. The fact that these systems are measuring supply functions is not the primary purpose of investigating them; rather it is the fact that each system is designed to measure the same functions in different ways, using different techniques, and for different uses.

Defense Integrated Management Engineering Systems (DIMES)

Definition

DIMES is a Department of Defense-wide program that is expressed as "an important element of the total DOD manpower

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[1]U. S., Executive Office of the President, Bureau of the Budget, "Progress in Measuring Work," Management Bulletin (Washington: U. S. Government Printing Office, August, 1962), p. 59.

management system aimed at improving manpower utilization in DOD industrial-type activities."[1] The system is defined as:

> The development and monitoring of programs and procedures encompassing performance measurement based upon the maximum economic availability of Engineered Performance Standards (EPS), production or manpower planning, material control, standard cost accounting, and training support designed to increase productivity and to reduce costs.[2]

Industrial-type activities are defined as:

> DOD activities providing products or services in categories such as depot level maintenance facilities, warehousing and supply activities . . . , arsenals and ordnance plants, shipyards, including support service and/or mass clerical operations related to the above.[3]

Purpose and Objectives

The major purpose of DIMES is to increase productivity and decrease costs in the Department of Defense. The Defense Establishment objectives are in line with the goals and objectives established in the Executive Branch of the U. S. Government. The Bureau of the Budget Circular No. A-11, 15 July 1964, Preparation and Submission of Annual Budget Estimates, states:

> Properly developed work measurement should be used to produce estimates of the costs of units of workload, in man-hours, such as man-hours per claim adjudicated, man-hours per man maintained in the field, man-hours per infested acre of pest control, etc., depending on the agency. These estimates should represent an acceptable level of performance based on current realistic time standards. Agencies are to extend the use of work measurement and unit cost analysis to both the common service activities and program activities.

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[1]U. S., Department of Defense, Office of the Assistant Secretary of Defense (Installations and Logistics), DOD Directive No. 5010.15, Defense Integrated Management Engineering Systems (DIMES) in DOD Industrial-Type Activities, December 22, 1965, p. 1.

[2]Ibid. [3]Ibid.

Bureau of the Budget Circular A-44, issued 3 October 1962, specifically pointed out that an effective manpower control program should include:

1. Analysis and appraisal of the work to be performed to assure that it is essential and will contribute to the accomplishment of agency objectives, and that appropriate targets and priorities are set.
2. Determination of manpower requirements, using principally the budget process but also such tools as work measurement, work standards, productivity analysis, and manpower and workload reporting.
3. Manpower control systems, using such techniques as manpower allocation, tables or organization reporting systems, special studies, periodic program reviews, and controls on filling vacancies.
4. Specific efforts to increase productivity through improvements in organization, work design, work methods, including simpler systems and mechanization, mathematical programming, supervision, and personnel management including skills inventories, employees, consultation, training, and incentive and motivation programs.
5. Selective test checks to ascertain whether the manpower control program is achieving the desired result.

DIMES Application

The Defense effort to achieve the objectives outlined above was organized as part of the OSD Cost Reduction Program and was delegated to the Assistant Secretary of Defense (Installations and Logistics) for implementation. The official directive establishing the program was issued in 1963. The initial approach to installing DIMES was through a phased installation in a few pilot facilities in each military service. Experience and technical data at these pilots was to be utilized to a maximum extent as additional facilities of a similar type were brought into the system.[1]

The current DOD directive states that: "As 'pilot' activities produce satisfactory prototype systems and procedures, they will be extended to other activities with similar functional responsibilities."[2]

The prototype DIMES programs shall include:

1. Development of improved methods.
2. Maximum economic utilization of EPS in performance evaluation.
3. Application of appropriate performance standards to production and manpower planning.
4. Standard cost accounting.
5. Utilization of labor-saving equipments.
6. Evaluation of resultant cost reduction contributions.[3]

The Department of Defense application of DIMES also provides for the selection and adequate training of qualified analysts for system implementation and maintenance. Also envisioned under DIMES is a DOD Standard Data Repository System for collecting, maintaining, storing, and retrieving standard time data to be used by DOD components for achieving EPS coverage.

DIMES in the Naval Supply Systems Command

Responsibility and Application

The Naval Supply Systems Command (NAVSUP) is responsible for installing DIMES in the supply functional areas within the

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[1]Lee Harding, Special Assistant to Assistant Secretary of Defense (Installations and Logistics) and Director of DIMES Project, "Outline for a Program to Develop Improved Management Engineering Systems," April, 1963.

[2]DOD Directive 5010.15, op. cit., p. 3.

[3]Ibid.

Naval Materiel Command. This responsibility extends to Inventory Control Points (ICP's), Naval Supply Centers (NSC's), Naval Supply Depots (NSD's), and the supply departments of Naval Shipyards (NSY's), Naval Air Stations (NAS's), and Construction Battalion Centers (CBC's). The Command is responsible for training DIMES analysts, guiding field activity program implementation, monitoring program implementation and providing continuing technical support and guidance.

The scope of application of DIMES under NAVSUP is directed toward achieving 100% coverage of personnel in terms of a work measurement reporting base. The 100% coverage figure is defined as the survey by DIMES analysts of 100% of an activity's funded complement less Public Works functions, and the attendant reporting of man-hours/work units as certified by DIMES surveys.[1] It is estimated that approximately 80% of an activity's on-board complement is susceptible to detailed (EPS) DIMES measurement techniques.[2] The 100% figure is indicative of the NAVSUP requirement for DIMES analysts to study all activity operations.

The NAVSUP DIMES policy specifically provides that:

> 1. The ultimate objective of the NAVSUP DIMES effort is the establishment/refinement of the existing manpower utilization and control system based upon engineered performance standards, with the attendant goals of

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[1]U. S., Department of the Navy, Naval Supply Systems Command, NAVSUPINST 5200.7A, Defense Integrated Management Engineering Systems (DIMES); Policy and Procedures Concerning, October 27, 1967, p. 1. (Encl.).

[2]Ibid.

maintaining and updating standards, developing operating improvements and further system refinements.

2. Engineered performance standards, when available, will be used for manpower management in preference to other techniques and tools such as historical standards, gross standards, staffing criteria tables, and so forth due to the more refined nature of DIMES standards.

3. Adequate staffs of analysts trained and qualified in the DIMES techniques will be maintained sufficient for the attainment of DOD and SECNAV DIMES Program implementation schedules. Management staff personnel who participate in special purpose or DIMES surveys should be trained and qualified in the DIMES techniques. Augmentation of staff analysts for DIMES as for other management improvement programs is expected normally to be funded from currently available resources.

4. Studies will be conducted whenever an area has not been formally surveyed during the previous two year period. Such studies may be initiated by system requirements, e.g., PMP/WGPMS, or to resolve locally defined problems. These studies will incorporate an examination of the manpower utilization and control system and when appropriate, conversion of the EPS to statistical standards.[1]

Background

The NAVSUP DIMES is being implemented using the successful approach and techniques of the well-known Methods Engineering Program (MEP). In fact, the only major difference between MEP and DIMES is in the name. The MEP has provided not only the time tested approach to developing performance standards, but a base of existing standards, data, and reporting systems that fulfill the DIMES prototype requirements.

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[1] *Ibid.*, p. 2.

The MEP received its initial start in NAVSUP (then the Bureau of Supplies and Accounts) with a pilot study in 1952. Two consulting firms tested the feasibility of establishing engineered performance standards on office type functions at two Navy facilities located in the metropolitan New York area.[1] One firm established performance standards in the issue control function of the Supply Department, New York Naval Shipyard, using Methods-Time Measurement. The other firm established standards employing time study.

The study results proved that office functions are susceptible to engineered measurement in the same way these industrial engineering techniques had been proven in private industry. Based on this initial success, additional contracts were let and by 1956 engineered time standards had been applied to a wide cross section of work performed at NAVSUP activities.

Initially, major emphasis was placed on the establishment of time standards and little was accomplished in the methods improvement area. Simultaneously, however, a separate methods improvement program aimed at operators and first line supervisors was being conducted. This division of effort and a lack of interest on the part of management for time standards reduced the program to little more than a sporadic effort by 1958.

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[1]C. K. Phillips, "Methods Engineering Program Pushed by BUSANDA," Navy Management Review, June-July, 1961, p. 5.

Late in 1959 a management evaluation study was made which revised the program by combining methods improvement with the methods measurement. Top management support was obtained, the concept of integrating engineered standards and statistical measurement was affirmed, and the training requirement for adequate MEP staffs was recognized. By the early 1960's the Methods Engineering Program was being implemented in all major supply centers and depots including four overseas supply depots.

NAVSUP DIMES Procedures

The NAVSUP DIMES survey procedure is a methodically arranged step by step process performed by a specially trained methods engineering staff organized in each activity. The DIMES studies are scheduled to meet local management survey needs, EPS coverage requirements, and system maintenance. Studies are conducted normally on an organizational basis (work center or group of work centers) by teams of management analysts. Surveys follow a standard pattern, unless they are special problem-action studies, commencing with supervisory and employee indoctrination and ending with a complete package of methods engineering products. The major products are reportable data elements to support the Manpower Utilization and Control System. These elements include: engineered performance standards for major jobs, time allowances for minor jobs; work units completed and backlogged for major jobs; man-hours allowed and actually used; and other supplemental data as local needs determine. Other major products of a typical survey are: standardized operating procedures; recommended staffing patterns; and often, time data that can be compiled as standard time data for other similar applications.

The NAVSUP DIMES survey is divided into two major segments. First is the methods analysis and improvement phase. The tasks and operations being surveyed are reviewed using selected methods study tools such as process charting and the "critical analysis" approach to methods study.

After methods have been thoroughly reviewed and improvements implemented, the second phase starts. This is the measurement portion of the study wherein appropriate jobs are measured and performance standards established. The major techniques of time measurement including time study, predetermined time systems, work sampling, and standard time data are used in complementary arrangements to develop the EPS.

Prior to, during, and following the survey, supervisory and worker personnel are in an indoctrination and training atmosphere as the DIMES staff promotes understanding, acceptance, and utilization of the procedures, standards and reporting system. A major feature of the MEP and DIMES effort in NAVSUP has been the attention given to developing favorable employee attitudes toward work measurement and assisting line management in recognizing the full potential of the system.

Under the NAVSUP approach, each activity is to establish a separate analyst team to identify work units and establish work content definitions for local statistical production rates in all organizational areas not yet surveyed in order to achieve a 100% reporting base as soon as possible. As the regular DIMES studies or surveys are completed in the areas where local statistical rates have been established, more refined manpower control techniques are established. The surveys also provide information on authorized but unfunded tasks, analysis of workload trends, and other management techniques useful to local management.

Staffing for DIMES' surveys has been suggested by the Office of the Secretary of Defense (I&L) to be on the basis of one trained analyst to each seventy personnel in the activity work force. All analysts participating in the NAVSUP DIMES receive methods engineering training in an eight week DOD Work Methods and Standards Training Course. NAVSUP maintains and administers a tailored version of this course that has been specifically oriented to supply operations.

Manpower Utilization and Control System (MUACS)

Currently NAVSUP is developing an integrated and automated Manpower Utilization and Control System. This system is a refinement and mechanization of the existing manual systems, and as such, will interface with standard cost accounting and the NAVSUP Management Information System (MIS). One of the criterion is that it must be capable of serving the information requirements of management at all field activity and headquarters levels. All DIMES standards, existing and future, will be aligned to the basic job order numbers to provide a suitable input arrangement for coordinated use of the DIMES' data in cost accounting, management information systems, manpower utilization and control, WGPMS, and other uses such as one-time reports. This system provides a more economical and efficient method of data collection, while assuring the accuracy of input data through the utilization of a uniform data base.[1]

Detailed individual DIMES standards and fixed allowances at each Uniform Automatic Data Processing System (UADPS) stock point will be aligned to the existing job order structure through the application of frequency distribution computations to develop composite type standards and allowances at the job order number level.[2] There will be only one composite standard or allowance for each combination of job order number and organizational component charging the job order number.[3] Under this method DIMES data will be collected and processed in the system coded so as to provide both organizational and functional performance information.

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[1]NAVSUPINST 5200.7A, op. cit., p. 2.

[2]U. S., Department of the Navy, Naval Supply Systems Command, NAVSUPNOTE 5000, Manpower Utilization and Control System (MUACS); guidance on restructuring processes for, December 29, 1967, p. 1, Encl (1).

[3]Ibid.

The MUACS has three key features that illustrate its essential characteristics:[1]

1. A separate data bank which will be off-line and use existing peripheral hardware at the UADPS stock points.

2. One-time input of common data will provide the source-data for specific management reports. All reports will be based upon various arrays of the same input data, thus providing improved accuracy and consistency of these reports.

3. MUACS, though designed for mechanizing and integrating local manpower and workload reporting requirements, is so structured that it is compatible with the present planning for the Naval Supply Systems Command Management Information System.

Major Advantages of the NAVSUP DIMES

1. The measurement of work is based on a rigorous application of accepted industrial engineering techniques. These techniques provide work standards that are reflective of "should take time"; i.e., engineered performance standards based on scientific methods of time measurement.

2. The system includes a strong emphasis on methods, procedures and layout prior to the measurement of time required to perform a task. Methods study prior to methods measurement

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[1]Interview with Mr. John Schanzenbach, Director, Methods and Standards Branch, Management Services Division, Administration and Organization, Naval Supply Systems Command, Navy Department, Washington, D. C., February, 1968.

increases actual and potential performance levels. Methods study also produces detailed step-by-step written procedures for job training and current "desk instructions."

3. DIMES develops, as part of the regular survey procedure, workload information valuable in assessing and improving methods and procedures. In addition, workload information generated for all major jobs during a survey enables the DIMES analysts to develop and recommend personnel staffing patterns based on the workload data and EPS.

4. In the NAVSUP DIMES, engineered standards are developed for jobs that can be identified to individual worker effort. With standards established at this level of work accomplishment, performance measurement can commence with the individual worker. By pyramiding standards and work units, performance measurement can be accomplished at successively higher levels, e.g., organizational, functional, or even on a program or project basis.

5. Data developed under DIMES can serve as a basic imput to a Management Information System. Standard times and workload information reported in DIMES can be useful in manpower evaluations and determinations relating to the successful application of a management information system employed at any level of management.

6. Under the NAVSUP DIMES all man-hours are accounted for including productive and nonproductive. This is accomplished by 100% coverage (including reporting) of organizational components.

All man-hours are accounted for in a DIMES covered work center, i.e., hours against standards, hours against work not covered by standards, supervisory hours, training, and all types of leave and administrative time. This complete coverage of time enables management to better evaluate overall performance and control manpower on an across-the-board basis.

Limitations of DIMES

1. One of the major drawbacks of the DIMES approach to work measurement is the time and effort required to perform a single study and establish detailed engineered performance standards. The time required to establish EPS is a major factor in any program utilizing this kind of measurement, but it is even more of a significant problem in Navy supply functions when there are a multitude of variable tasks and a high percentage of clerical/administrative jobs on the borderline of being economically measureable.

2. Another serious limitation found in systems like DIMES is standards maintenance. As DIMES coverage is expanded, more and more time standards come into existence increasing the effort required to keep them accurate. In Navy supply functions this is a serious problem. Methods and procedures change frequently in the supply business. Outdated standards can be more than useless when they do not reflect actual requirements; they can cause erroneous and harmful manpower decisions. Limited DIMES staffs are hard pressed to achieve new coverage and at the same time maintain existing coverage.

3. DIMES requires a considerable amount of detailed data to be collected and reported. Individual reporting under standards requires that each worker record and report on a scheduled basis, man-hours and work units. When considered in the aggregate this amounts to considerable paper-handling, summarization and computation. In many cases where individual reporting and performance evaluation may be desirable and beneficial, it is not accomplished for these reasons. The savings of effort (and cost) by eliminating some reporting of data may be prudent; however, this should always be balanced with the nature and purpose of the standards--at the time they are established.

4. Growth of automatic data processing in supply functions has changed the nature of many tasks; tasks that were once susceptible to detailed measurement may no longer prove economical for EPS. Computerization removes the manual effort from many white-collar jobs leaving tasks requiring more mental effort at higher skill levels. These jobs are not as "measureable" under the DIMES approach as their forerunners. This factor limits the extent of useful application of EPS in some supply functions.

5. DIMES studies are conducted on an organizational basis and relate to functions of work only through the grouping of individual standards. By following organizational boundaries many functions are only partially covered by DIMES measurements. This condition is only remedied when 100% activity coverage is achieved, or when temporary statistical standards are established in advance of complete DIMES surveys. Thus, complete functional measurement is seldom realized until late in the implementing process.

NAVSUP Work Measurement System

The NAVSUP Work Measurement System, with the Allotment Administration and Accounting Reporting Systems, make up the composite NAVSUP Supply Management Reporting System. The three sub-systems are related through the establishment of a common system of functional classification which fully integrates the systems.

The Work Measurement Systems is employed as a means of relating personnel and requirements to the measured workload required to accomplish NAVSUP programs and functions. The principal objectives of the NAVSUP Work Measurement System are:

> 1. To provide a factual basis for management planning and budgeting for NAVSUP operations at all echelons of command, and
> 2. To bring about management improvement at all levels through continuing evaluation of current operating practices.[1]

The NAVSUP system measures group performance of functions or types of work based on statistical standards, as distinguished from individual performance standards established under DIMES. The System consists of:

1. The identification of units of output which represent functional end products, i.e., documents, measurement tons, packs, etc.

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[1]U. S., Department of the Navy, Naval Supply Systems Command, NAVSUP Publication 285, NAVSUP Management Handbook, July 21, 1966, Chapter V, p. 5-3.

2. The recording and reporting of total group effort, i.e., man-hours required for production of these units.

3. Relating total effort expended to functional end products, i.e., a production rate.

Not all work or types of work produced by the groups are measured directly. Collateral work necessary to produce the end product is indirectly reflected in the overall productivity obtained by the group.

Under the NAVSUP Supply Management Reporting System a function is defined as:

> A defined operational or work area which may or may not be related to a formal organizational unit. For purposes of supply management reporting, this definition also includes cost items which are not related to specific functional areas.[1]

Basically, the NAVSUP Work Measurement Reporting System provides, on a functional basis, integrated historical data on:

1. Work units accomplished and backlogs.
2. Production rates experienced.
3. Manpower utilized.
4. Costs incurred.

In integrating work measurement, allotment administration, and cost accounting, NAVSUP has aligned work measurement, allotment, obligation, and functional account data. The man-hour data required for work measurement reports are derived from the

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[1] _Ibid_., p. 5-5.

same source which provides obligation and expenditure data--i.e., the accounting job order system. Accordingly, job order systems are arranged to provide accumulation of man-hours concurrently with the accumulation of obligation and expenditure data--within the framework of the functional definitions. In addition to providing a simplified device for accumulating management data, an integrated job order system provides local management with a valuable mechanism for internal control purposes.

Statistical standard production rates are developed from past performance data (computed by dividing work units reported by man-hours expended), combined with a certain degree of managerial judgment by determining the level of productivity which can reasonably be expected. With the advent of, first, the Methods Engineering Program, and currently DIMES, the functional distribution of effort and broad workload indicators provided by the Work Measurement System are complemented by the detailed measurement of tasks performed in organizational components. The combination of data generated under broad functional production rates (Work Measurement System) and detailed job standards (EPS) provides all levels of management with additional information to be used in evaluating performance in relation to workload, manpower, and funding.[1] As previously indicated, the DIMES reporting system also serves as a basic feeder report for Work Measurement wherever it is installed.

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[1]*Ibid*., p. 5-7.

Procedures have been developed for determining "Integrated Standard Production Rates" based on reported functional and job performance data. The integrated production rate is, in effect, a statistical rate for a function adjusted by the performance level achieved in that function on the tasks actually measured by EPS. The greater the coverage of a function by EPS, the greater the significance of the performance against the detailed time standards. The development and use of integrated standard production rates require that man-hour and work unit reporting be uniform and consistent and that engineered performance standards be maintained to reflect current operating methods and procedures. Otherwise an integrated rate may reflect erroneous performance and productivity levels.

NAVSUP field activities are assigned specific responsibilities in connection with the operation of the Work Measurement and Supply Management Reporting systems. They are:

> 1. Insuring effective operation of the work measurement and cost accounting systems within the field activity;
> 2. Utilizing performance data generated by the work measurement and cost accounting systems to the fullest extent possible in the budgetary process, and in effecting local management improvement;
> 3. Training, indoctrination and orientation of personnel in staff and operating units of the activity in all phases of the system;
> 4. Insuring the maintenance of consistency and accuracy in work measurement and cost accounting recording and reporting;
> 5. Developing proposed improvements in the work measurement and cost accounting systems and making appropriate recommendations to NAVSUP;
> 6. Preparing and submitting prescribed reports to NAVSUP.[1]

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[1]*Ibid*., p. 5-6.

Advantages of the NAVSUP Work Measurement System

1. The simplicity and relatively low cost to implement and maintain are major advantages. The system does not require extensive or expensive training to install (and maintain) and is easily understood in principle and application.

2. Statistical standards (functional production rates) do not become obsolete or require "rewriting" due to small changes in methods and procedures.

3. Statistical measurement has a high degree of applicability to office type operations involving more mental than manual effort, e.g., planning and administrative functions.

4. This system, being integrated with allotment administration and cost accounting, offers a more effective management tool by permitting the analysis of workload, manpower utilization, and cost accounting on a common and realistic basis.

5. The integration of EPS into the statistical production rate provides a better indication of true performance than a purely historical rate.

Limitations of the NAVSUP Work Measurement System

1. The statistical measure of performance (the production rate) based on historical production record is not an absolute measure of effectiveness, i.e., is not truly an objective standard. Such measures compare performance with an arbitrarily selected base period and require subjective analysis and modification to

account for such factors as significant changes in workload, method, and physical surroundings. A statistical production rate may describe a trend of effectiveness within the measured group, but there is not a consistent definition of what a normal expected work pace should be unless supplemented by an aggressive methods analysis and improvement program.

2. Inherent in historical based production measures is the danger of perpetuating method and procedure inefficiencies as well as below "normal" work tempo and unnecessary delays and operations.

3. Statistical production rates employed in this system are general and approximate and cannot readily be used to evaluate effectiveness of individual employees.

4. Broad functional measurement based on single workload indicators is subject to providing erroneous measures of total effort (manpower) expended within the function. There may be operations or jobs within the function that have inputs and outputs not related to the unit of count being used to measure the total function. This "unmeasured" effort could be significant in terms of manpower consumed and work accomplished.

Warehousing Gross Performance
Measurement System

System Definition

The Warehousing Gross Performance Measurement System (WGPMS) is a system designed to provide a quantitative measure of warehousing manpower consumption to be used by the military services, the Defense Supply Agency (DSA) and the Department of Defense, Office of the Assistant Secretary of Defense (Installations and Logistics). It is based upon standard methods and engineered time standards covering fundamental warehousing operations performed in supply activities and depots.

The purpose of WGPMS is to provide for:[1]

> A. A coordinated program for the development and adoption of warehousing standard methods including the quantitative measures for utilization of warehousing manpower.
>
> B. The establishment of production units, earned hours, actual hours, and performance indices which, to the extent practicable, will provide numerical indicators of performance. These data will be used for management analysis and budget review of warehousing operations and determination of manpower utilization trends.

The application of the system is related to the cost accounting structure provided for in the DOD-wide uniform accounting system. The WGPMS covers those functional cost codes included in the Storage and Warehousing series. This series relates to the receipt, storage, issue and shipping of material at Defense warehousing installations.

The scope of the WGPMS is DOD-wide including all services and the Defense Supply Agency. All major supply and warehousing activities in the continental United States are required to report

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[1]U. S., Department of Defense, Office of the Assistant Secretary of Defense, Installations and Logistics, DOD Directive No. 5105.34, Defense Supply Agency (Warehousing Gross Performance Measurement System), July, 1965, p. 1.

under the WGPMS.

The objective of WGPMS is as stated in the Department of Defense Directive 5105.34-M, Defense Supply Agency (Warehousing Gross Performance Measurement System):

> Cost reduction or cost avoidance in the performance of effective material support can be achieved or enhanced by economy in the use of logistics resources and by efficiency in executing logistics operations. . . . The basic objective of the program is to provide an effective management tool for higher headquarters as a basis for decisions relating to comparisons, review, evaluation, transfer, consolidation and/or distribution of warehousing resources, when necessary in the national interest.

Logistics Management Institute Study

In 1962 the Department of Defense made a contract with the Logistics Management Institute to develop valid and reliable quantitative measures of warehousing efforts. The study was performed by A. T. Kearney and Co., a management consultant firm located in Chicago, Illinois. Their report outlined a system, based on generally recognized industrial engineering techniques, that would furnish a means by which the Department of Defense could make valid depot performance comparisons, exercise control, and determine manning changes caused by stock relocation or change in weapons systems. It was envisioned in the report that the same procedure could also be used as a basis for control of performance at any depot organization level.

Development of the System

Although various statistical indices relating warehousing manpower to tonnage or other single yardsticks were being used to show trends the consultants determined that true comparisons among depots could not be made in any way other than from a foundation of engineered time standards. These standards would need to cover all of the fundamental warehousing operations that occur in typical depots throughout the country and reflect the effort of all major variable factors. It was found in the study that wide variations in tons per man-hour can be encountered as densities, piece weight, line items and payload change. The use of tonnage or any other single factor to compare manning of most warehousing operations was considered an impossible solution to valid measurement. Thus it was proposed that all repetitious work involved in the warehousing functions, i.e., receiving and issue, be broken down into universal tables and time formulas reflecting all the significant variable factors.

Standard Performance Times

A review of the existing depot time standards indicated that they were set up previously for local conditions and, naturally, showed a wide variation in crew size, handling methods, and facilities since they covered operations as they actually existed. Thus the standards varied from depot to depot for the same operations. Since they were not founded on data from a single source, and did not incorporate the complete range of variation required, it was determined that it was not possible to use them as an overall system in developing the time formulas and data needed for comparative analysis between depots.

It therefore became a requisite of the study to develop a uniform means of expressing time measurement which would be usable at various levels of control and could be applied at any installation. The time data system outlined by A. T. Kearney and Company and further developed by the DOD, consists of time data and formulas that can be arranged in a building block fashion in order to provide a total measuring yardstick. The four time data levels building to the yardstick (Composite standards) are:[1]

> Basic Data: Using a predetermined time system and time study, time values were established for elements of work which are common to one or more warehousing operation. Example: open and close a paper bag.
>
> Extended Data: Combinations of a series of Basic Data elements which are common to one or more warehousing operations. Example: stack empty pallets.
>
> Specific Standards: Combinations of Basic and Extended Data that establish time values for specific tasks which represent a segment of a total task. Example: prepare a boxcar for loading.
>
> Total Standards: Combinations of Basic and Extended data plus Specific standards that establish time values for a total job. Example: load a 40 ft. boxcar--solid load.

By combining certain Total Standards based on their frequency of occurrence, time values or Composite Standards as they are called, can be established to measure overall tasks of a warehousing activity. For example: loading or unloading railcars

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[1]Maurice P. DeRobertis, "DOD's Warehouse Gross Performance Measurement System," Newsletter, Magazine of the U. S. Navy Supply Corps, XXVII, No. 2 (February, 1965), p. 20.

or trucks. The compilation of Composite Standards based on a selected set of acceptable methods covering all normal handling and related activities provides a gross measurement technique that precludes the need for local standards installed at each specific depot.

Simply stated, Composite Standards are weighted production standards of sufficient stability representing standard times which, when multiplied by reported work units of an activity, yield credits that can be applied against actual hours expended to provide a gross index of productivity. The Composite Standards are not designed to measure crews or individual work assignments. They are applied on a mass basis to selected input and output work unit counts after certain samplings and distance measurements have been made to apply the time data to local warehouse layout and average piece weights and densities.

Standard Warehousing Methods

Basic to the ability to compare depot performance on the basis of Composite Standards is the requirement for acceptable standard warehousing methods. The A. T. Kearney and Company outlined basic principles associated with good warehousing practices. The Department of Defense then developed an initial seventy-five "standard methods" upon which the time data (outlined above) were established. Standards which include local inefficiencies would not identify variances to management that are correctable. For this reason, the standards for gross measurement provide for doing similar work in the same manner at all activities with variations reflected only for such things as distance, density, and other fundamental local conditions.

Warehousing Operations and Functions

The WGPMS measurement and reporting covers those warehousing operations included in the physical handling of material and accompanying paperwork, into and out of warehouses. Operations involving forklift trucks, weight handling equipment, trucks, railroad cars and basic mechanical aids are included in the system application. Such operations as loading and unloading trucks, moving material in and out of storage racks, packing and crating, and care of material in storage are typical of the work covered by the WGPMS.

For accounting purposes the operations performed in Defense warehousing are categorized by Functional Account Codes. This structure of cost accounting codes provides the foundation upon which the WGPMS measurement and reporting system is based. The codes include definition and scope of operations included in each function and the data element to be reported, i.e., manhour charges.

Warehousing Composite Standards

There are presently fourteen Composite Standards covering warehousing operations at field activities. These standards are derived for each individual activity based on the predetermined Basic, Extended and Specific time data and certain work mix, density and line item data collected from the activity by means of a questionnaire. This questionnaire is completed by each activity based on a two to three week sample taken semi-annually. The data obtained by the questionnaire are applied to the predetermined time values and Composite Time Standards are then derived for each activity.

Production Units and Man-hour Data

The WGPMS report submitted by warehousing activities includes production data and man-hours covering the work accomplished for a specific reporting period. Production data include those output measures necessary to apply the Composite Standard and conventional output measures consisting of line items, short tons and measurement tons. The receiving, packing and issue functions are covered by Composite engineered standards and are referred to as engineered functions. Both WGPMS output measures and conventional output measures are reported for these functions. All other functions report only conventional work counts and are referred to as non-engineered functions. Actual man-hours consumed are reported for both engineered and non-engineered functions. Total labor costs for all of the storage and warehousing functions are reported by each activity. Specific instructions are provided by the appropriate DOD directives for interpreting and collecting the required production and man-hour data.

The WGPMS Reporting System

The WGPMS reporting system provides for the submission of the Production and Actual Hour Summary to the Defense Warehousing Measurement Office, Defense Supply Agency via the respective service headquarters. The various DOD management levels involved and their major responsibilities are as described below.

Warehousing and Supply Activities

Reporting activities are responsible for implementing the approved warehousing methods, where applicable, and for collecting and reporting production and man-hour data to their service headquarters. Activities are expected to develop and maintain effective procedures for collecting and auditing all reported data. Review and utilization of the information provided by the report is determined by local command interest and service headquarters' requirements.

DOD Components (Service Headquarters)

Headquarters of the various services and DSA are charged with implementing and monitering the WGPMS in their field activities. They are expected to review, analyze, and comment on the performance reports submitted via them to the Defense Warehousing Measurement Office (DWMO). In coordination with the DWMO they are responsible for the maintenance and further development of the system. All DOD components have designated staff elements or sub-agencies to coordinate, implement and maintain the WGPMS. Representatives are assigned to work with the DWMO in performing these responsibilities.

Defense Warehousing Measurement Office

The Defense Supply Agency (DSA) has been assigned by the Secretary of Defense to manage the WGPMS. The DWMO has been established in DSA to carry out this responsibility. This office, in conjunction with the DOD components, developed the system initially proposed by A. T. Kearney and Company and is currently managing the reporting system for the Office of the Secretary of Defense (OSD). One of the office's major responsibilities is to review and analyze the WGPMS report for OSD and prepare management reports on system performance. The DWMO develops and revises all time standards (Composite Standards) and standard methods for WGPMS application.

Assistant Secretary of Defense for
Installations and Logistics, ASD(I&L)

The Assistant Secretary and his office have the primary responsibility for issuing policy direction in connection with the implementation and operation of the WGPMS. They are responsible for the coordinated utilization of the system at the OSD level, including comptroller and manpower interest areas. WGPMS Summary Management Reports are received quarterly by the ASD(I&L) from the DWMO.

Evaluation of WGPMS Reports

The major evaluation technique employed in the WGPMS is comparison. Comparisons of reported data are performed and are intended to be performed at the activity, service headquarters, DWMO and OSD level. Warehousing activity's comparison of WGPMS data is essentially that of period to period and function to function. As reports are reviewed at successfully higher levels of management, comparisons are made between activities and services.

Advantages of WGPMS

1. The performance measurement in this system is based on composite standards developed with standard time data. Thus, the system has an engineered base with the major benefits that accrue from an EPS type measurement.

2. The system is uniform in methods, terminology, basic time data and reporting procedures DOD-wide. This is the first work measurement system that permits direct communication and comparison between the services.

3. The system is tied directly to the DOD cost accounting structure and permits functional evaluation of dollar costs as well as manpower performance.

4. The standard time data developed for WGPMS is easy to understand and apply. Once certain workload and workload characteristics for a particular activity are known, WGPMS

performance standards can be developed with little effort, using the standard time data. No on-site measurement is necessary.

5. The WGPMS standards for an activity provide a means of work analysis by comparing them with local DIMES standards. This comparison can be made where DIMES standards have been established in warehouse functions covered by WGPMS. This comparison can assist local management in evaluating its performance under WGPMS by identifying methods, facilities, and work mix differences that are peculiar to that activity.

Limitations of WGPMS

1. WGPMS has basically the same maintenance problem as DIMES except that there are fewer standards to maintain and they are less sensitive to minor changes in work mix and other controlling factors. A shift in workload or type of work can cause a WGPMS standard to become invalid.

2. A major limitation of WGPMS is that it is essentially designed for wholesale type warehousing operations and not base support type warehousing. A large portion of Navy supply effort in warehousing functions is devoted to base type support, e.g., air station and ship yard supply departments and to some extent supply centers. Methods and procedures vary widely in base support supply operations depending on local needs and are not always adequately reflected under the standard methods designed for general WGPMS application. Hence, valid performance evaluation becomes more difficult and in most cases less meaningful.

3. In most Navy warehousing activities WGPMS has been superimposed on the DIMES; that is, DIMES standards already exist in the warehousing area and are being used for performance evaluation and control by the activity and to a certain extent by NAVSUP. With WGPMS standards applied to the same functions and system performance being reported to OSD, local management is confronted with two systems that are often not reconcilable. Although comparative analysis may be beneficial in some cases, local supervisors and workers can be confused and dismayed by too many different measures of the same operation.

4. Local activity use of WGPMS is limited. Except as noted above for comparison purposes, the WGPMS measurement data are too broad and functionally oriented to provide local management any meaningful control tools.

5. WGPMS broad-based composite standards contain variables that require frequent investigation to ensure that changes or extreme fluctuations are properly accounted for. If workload and workload mix data are not sampled on a complete and frequent (at least every three to six months) basis, there is no assurance that performance times are reflective of the activity's true performance. The accuracy of the sample is subject to all the conditions associated with any statistical sampling technique, including length and size of sample.

Triplex Analysis and Comparative Summary

The three systems discussed above are not wholly independent of each other, nor are they completely integrated. They are three work measurement systems designed and implemented to achieve basically the same objectives, i.e., cost reduction and manpower control.

One major distinction can be made between the three systems--their primary purpose or use. This essentially determines their design and application. Generally, the NAVSUP work measurement system is for activity-wide measurement and evaluation, and for budget preparation and funds allocation. DIMES, although supportive to the work measurement system, is primarily for local manpower management and control. WGPMS, on the other hand, is primarily a system for evaluation, on a functional basis, of manpower utilization for use by higher levels of management, i.e., component headquarters and the Office of the Secretary of Defense.

The systems, with varying approaches to measurement and reporting, are not totally free of some duplication or overlap. This situation can be partially attributed to the fact that they were developed and installed at different times and the procedures for implementing the system in each activity were not spelled out in detail. This latter situation is common in any large organization where individual activities must have freedom to develop procedures that are adaptive to local conditions. However, without systems coordination at the higher levels of management there can be little coordination expected or attained at the lower (activity) levels.

The greatest amount of integration of systems so far achieved is with the NAVSUP Work Measurement System and the NAVSUP DIMES. The overall NAVSUP manpower control system is reflective of this integration. The system serves management in three well defined areas:

1. Bureau budget formulation and negotiation with the Navy Comptroller and Department of Defense.
2. Bureau allocation of operating funds and manpower ceilings to field activities.
3. Field activity internal distribution of resources for accomplishment of work.[1]

At the higher levels of budget formulation, force levels, i.e., the number of ships, planes and personnel, are correlated with major workload indicators in the supply management and supply operations areas. In supply operations--receipt, storage, issue, etc.--for Navy logistic support, force levels are related to major workload indicators--line items issued and received, measurement tons issued and received, and measurement tons in storage. Changes in force levels can be translated into workload and funding requirements. These three indicators are too broad for use in distributing resources to field activities. For this level, approximately 100 functional breakdowns of workload have been made.

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[1]Norman S. Peterson, "Evolution Not Revolution--BUSANDA's DIMES Application," Navy Management Review, X, No. 9, September, 1965, pp. 10-11.

The NAVSUP Work Measurement System ties in directly at this point. Collection of man-hours and work units under this system allows the computation of statistical production rates for each function. DIMES enters at this point in the overall system by providing the standards for determining an integrated (engineered/ statistical) production rate. Field activities prepare operational plans which forecast workload and manpower requirements based on these production rates. At the activity, work is accomplished by organizational components while resources required are determined on a functional basis. DIMES coverage, being related to both functions and organizations, is used (when available) to allocate and control the local manpower resources.

The relationship between NAVSUP DIMES and WGPMS is less well defined and organized than NAVSUP DIMES and NAVSUP Work Measurement. Each activity is basically responsible for ensuring that duplication of basic measurement does not occur. DIMES coverage of warehousing functions was relatively complete in NAVSUP field activities before WGPMS was implemented. Consequently, many activities now find that, in effect, two basic time values are in existence and use for the same element of a warehousing operation. Although the times are used for different purposes (local vs. OSD) and relate to performance standards at different operating levels, confusion and doubt as to appropriate methods and valid times can result.

One important concept that was originally recommended when WGPMS was first envisioned was that a measurement system would be developed for the short range based on gross composite standards to give early data for higher levels of management. Then, on a long range basis, refined engineered standards to permit more intensified management at the activity level would be developed. It was not made clear whether these refined standards would replace the composite standards or supplement them. Today NAVSUP activities have both DIMES and WGPMS standards in most warehousing functions.

The extent of current guidance concerning DIMES and WGPMS coordination is represented by the following:

1. NAVSUP Instruction 5200.7A of 27 October 1967; Defense Integrated Management Engineering Systems (DIMES); policy and procedure concerning:

> Management reporting requirements served by basic DIMES feeder reports will be integrated to the maximum practical extent to include data for standard cost accounting, the Warehousing Gross Performance Measurement System (WGPMS), and other similar reporting systems.

2. DOD Directive 5010.15 of 22 December 1965; Defense Integrated Management Engineering Systems (DIMES) in DOD Industrial Type Activities.

> The prototype DIMES programs developed in warehousing functions shall provide for coordination with Warehousing Gross Performance Measurement System standards with such adjustment as may be required to accommodate provisions of paragraph 11-103.3 of DOD Manual 5105.34M.

Paragraph 11-103.3 of DOD Manual 5105.34M, Warehousing Gross Performance Measurement System, states in part:

> The basic and extended data and the specific standards may have direct application within an activity or may be adjusted, by such factors as distance, weight, etc., and

then used. Such use should speed the development of engineered standards and eliminate the repetitious generation of times for work elements which vary only minutely.

3. DOD Directive 5010.15.1-M (Manual); Material Handling Standard Time Data (1 March 1967).

1-12 Production Standards. The two work measurement programs, WGPMS and DIMES, produce production standards which generate reports that are used to assist Department of Defense and Service Headquarters in making management decisions. These decisions may become arbitrary if no work measurement data is available. WGPMS applies standards to selected functions using controlled methods within the limits of existing physical resources. This gross "should take" manhour time applied to the total output of an activity, makes possible an evaluation of all three factors, Methods, Facilities and Production Performance. DIMES is compatible with WGPMS, and is necessary for local management decisions. Actual conditions, frequencies of occurrences, material densities, distance, etc. can be included in the local finite standards program. Local standards reports provide local management a tool for evaluating production of effectiveness.

a. The integrity of the DIMES program will be maintained with a primary purpose of satisfying local management needs.

b. The Warehousing Gross Performance Measurement System (WGPMS) will be maintained to satisfy Service/Agency Headquarters and DOD Level Management needs.

c. The two systems are compatible. They are assimilative, capable of contributing to each other as part of an integrated management reporting system. Each employs engineered performance standards as a management tool available for the evaluation of operating effectiveness at all levels of management.

The above instructions provide an indication of what is expected and required in functional areas measured by both DIMES and WGPMS. However, individual activities are for the most part guided by their own interpretation concerning local integration of time data and reporting under the two systems.

The relationship between WGPMS and the NAVSUP Work Measurement System has not been clearly defined in any written NAVSUP instructions or procedures. Again, in the case of these two systems, it appears that activities are expected to develop local procedures that will provide for a smooth interfacing of the systems. Although many man-hours and work unit counts are identical under the two systems, reporting requirements, including frequency, channels, and content preclude efficient integration of all data. Progress is being made in all three systems to consolidate data for reporting purposes, but until more definitive efforts are made to coordinate the systems at the higher levels of management, little more than "paperwork" integration can occur at activity levels.

Summary

Basic to the application of any work measurement system are the criteria or factors that should be considered in designing and installing a system. Of major concern are: management support; a need or reason for measurement; and recognition of variables that will affect the type of measurement, type of management reports, and results expected.

There are three major work measurement systems being applied to the supply functions in the Navy. The Defense Integrated Management Engineering Systems (DIMES) represents management interest in providing detailed measures of work and performance for activity management control purposes. This system is based on the establishment of engineered performance standards and reporting systems designed mainly for the first level supervisor and, as desired, other levels of local management. In contrast, the Warehousing Gross Performance System (WGPMS) is designed primarily for use by levels of management above the activity. It covers only the warehousing functions and is based on a DOD-wide uniform structure of methods and time data. Performance measurement obtained through this system is intended to provide broad-based indicators of manpower effectiveness that can be compared to those of similar type activities. Although WGPMS measures performance based on engineered time data and specified work counts, the scope and detail of WGPMS Composite Standards differ from the DIMES standards covering the same warehousing functions.

The NAVSUP Work Measurement System provides a statistical measure of work performed at a level higher than both the DIMES job standards and the WGPMS Composite Standards. Production rates are developed for each supply function including those of warehousing. Consequently, in a Navy stock point any one of several warehousing functions may have three measures of manpower performance applied to it. One measure (DIMES) would represent performance aggregated from the detailed job standards (or time allowances) established within that function; another measure (NAVSUP Work Measurement) would represent performance reflective of the total man hours used in the function related to the key work unit produced; and the third measure (WGPMS) would represent performance established by a means that may be considered halfway between the other two--that is, partially statistical and partially an engineered measurement. The means of achieving full integration of these systems are developed in the next chapter.

CHAPTER V

PROJECTION OF A FULLY INTEGRATED WORK MEASUREMENT SYSTEM

In attempting to project or define a fully integrated work measurement system it may be wise to first define the word "integrate." Webster defines integrate: "To form into a whole; to unite or become united so as to form a complete or perfect whole; unify . . . ." Funk and Wagnalls provide essentially the same definition: "To make into or become a whole; give the sum total of." The word has been used relative to work measurement before. The Navy Manual for the Integrated Work Measurement Program in 1950 stated that:

> In the development of such work measurement programs, provision must also be made to include such portions of the programs of other bureaus and offices having responsibility for developing Navy-wide criteria in the field of "Common Services" as such bureaus and offices may deem appropriate.
>
> Such an approach will enable those bureaus or offices which have technical responsibility for a particular function or service to evaluate the effectiveness of performance on a functional basis, and to establish, as appropriate, Navy-wide yardsticks for these functions or services. Such a program would provide for the integration of all programs insofar as common services are concerned, and for that reason is called the Navy Department Integrated Work Measurement Program.[1]

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[1]Department of the Navy, Manual for the Integrated Work Measurement Program, op. cit., p. 8.

In this case the "integrated" in Navy Department Integrated Work Measurement Program referred to the unifying of all related work measurement programs.

A current use of "integrate" in work measurement is found in DIMES (Defense Integrated Management Engineering Systems). The Department of Defense Directive on DIMES states, under Purpose and Objectives:

> This Directive establishes a DOD program setting forth policies and guidelines to integrate the several levels of management responsibility required to achieve the goals and objectives established.[1]

In this case "integrate" refers to the uniting of various levels of management responsibility to achieve certain objectives.

In this paper the basic definition of "integrate" remains unchanged but is applied more to the elements or factors that comprise or result from a work measurement system; e.g., personnel, measurement techniques, reports, system coverage and uses.

The projected system concepts and elements are developed from the material discussed in Chapters III and IV. Because these chapters covered techniques and applications found in the Navy supply functions, the concepts or ideas that follow necessarily apply to the same functional areas.

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[1]DOD Directive 5010.15, <u>op. cit</u>., p. 1.

Outline of a Fully Integrated Work Measurement System

Requisite Components

Activity Work Measurement Staff

The activity work measurement staff should be highly trained in the skills and techniques required to support all phases of a work measurement system. This requirement includes methods analysis and improvement as well as skills in engineered measurement techniques and standards setting. The staff should have complete knowledge and understanding of the activity's accounting, budgeting and management information systems. There should be participation of the staff in all systems and procedures analysis, development, and improvement that relate to or affect work measurement in order to ensure complete consideration of work measurement requirements and objectives. The activity work measurement staff should be responsible for all work measurement programs or systems existing in the activity; e.g., the NAVSUP Work Measurement System (Supply Management Reporting), DIMES, and WGPMS. The staff should be sufficient in size and capable in skills to provide the necessary support for all work measurement requirements. These requirements are basically: (1) Organizational or functional surveys for methods analysis and improvement, establishment of work standards, and development of reporting and control procedures; (2) Maintenance of methods, work standards, and reporting and control procedures on a continuing basis; and

(3) Training and indoctrination of employees and supervisors in work measurement principles, applications, management uses and benefits. The work measurement staff should be located in the same organizational component of the activity assigned the staff management engineering responsibility.

Methods Analysis and Improvement

The work measurement system should include, as part of its fundamental application, method analysis and improvement as related to the work being measured. The methods analysis and improvement effort should precede the establishment of work standards. Methods study should also be accomplished whenever procedure and/or system changes dictate method changes. The methods study and improvement should be accomplished by the work measurement staff. Overall systems and procedures analysis and development should be accomplished by other appropriate management engineering personnel; i.e., systems designers, management analysts, or however designated.

Measurement of Work

This is the most critical and costly phase of a work measurement system. The development and application of work standards should constantly be reviewed and appraised by the work measurement staff in conjunction with the line managers concerned with the system's use and objectives. Decisions on what work to measure and how best to measure it should be in consideration of local management requirements as well as the directives from group standards should be a major objective. Work standards should be established so as to permit the summation of work measurement data on both an organizational and functional basis; that is, detailed work standards (both individual and group) should have a scope of coverage and coding that is identifiable to one organizational component and one functional account (DOD uniform cost account structure).

Basic to the effective measurement of work and continuity of the work measurement system is the maintenance of the work standards. All work standards, particularly engineered standards, should be reviewed periodically for validity of measurement and accuracy in reported performance. As changes in systems, procedures and methods occur, time standards must be re-established or adjusted to reflect these changes. Periodic audits of work count and man-hour reporting are required to ensure accuracy in both workload and manpower performance information.

Systems Interface

The work measurement system should interface with the other data collection systems of the activity. The work measurement system should be compatible with and supporting to the budget and accounting systems and other management information or reporting systems. Duplication of collection and reporting of data should be eliminated by combining all reporting requirements at the lowest level of data development. By relating all accounting, manpower, and workload data to a common and well defined management control device such as a "job order" an interfacing of work measurement and other management systems can be achieved. This is the approach under the NAVSUP MUACS plan. The job order number provides, in addition to the fundamental budget and accounting information and control, a means whereby work measurement data may be collected and identified for a multitude of uses. Work standards can be structured or restructured to provide composite measurement of work under each specific job order. This measurement and performance data can be utilized for both internal manpower control purposes (DIMES) and external reporting for systems such as WGPMS. Work measurement data collected via a job order system also permit further summation for organizational performance evaluation and control and development of functional production rates for budget preparation and execution. In addition, work measurement data collected and handled through a management control device (such as a job order system) should provide a basic input into a management information system (internal and external) that requires workload and manpower data. Maximum utilization of computer capability should be made where systems interfacing accomplishes consolidation and collection of data at a common level of input.

Cogent Applications

Manpower Utilization and Control

A fully integrated work measurement system should essentially be employed to provide management, at various levels within the organization, manpower and workload data that will be helpful in management decision-making. Manpower measurements developed in the system should be used to balance workload and personnel assignments and to appraise the results of this balancing effort. Feed-back on work accomplishment, backlog and available man-hours is an essential element of the manpower control process. The assignment of work or workers on the basis of work measurement information (workload and time standards multiplied to determine required man-hours) should be accomplished to achieve maximum utilization of personnel. After-the-fact performance evaluation (earned hours compared to actual hours) should be used not only to appraise the worker but also the ability of the supervisor to effectively use the controls made available to him. A careful analysis of current workload, workload trends, present and past group and individual performance, and work standards should equip the supervisor with sufficient information to exercise effective manpower utilization and control. If work measurement usage is limited to only after-the-fact performance evaluation and no attempt is made to plan or schedule work or worker assignments based on measurement information, then the work measurement system is not effectively being applied for manpower utilization and control.

Management Information

The use of work measurement information for other than immediate work and worker evaluation and control purposes should be considered as a potential application. Vast amounts of workload, manpower, and performance data are collected, reported and disposed of in activities where work standards are installed. A fully integrated work measurement system should, through its computerized operation, provide for the retention of selected data for input into higher-order management information systems on an as required or exception basis. Special studies, problem area surveys, and overall system analysis would benefit by having access to retained data collected and filed through an integrated work measurement system.

Budget Formulation and Execution

Work measurement has always played a significant role in preparing budget requests and in the distribution of allotted funds. A fully integrated work measurement system should play an even greater role by providing management more effective indicators of both manpower requirements and performance. If 100% coverage of the activity's work is realized and composite work standards are developed for each job order (and hence cost account) a work standards base will exist that provides more definition and quantification to the work effort being funded and accounted for. Although this will not provide an absolute base for determining the amount of funds required, it will relate a man-hour to workload planning factor that was heretofore either dispersed at the individual job level or accumulated at a higher level (i.e., supply function) on a purely statistical basis.

Direct application of the "job order standard" to budget preparation and execution may never become totally feasible due to several unmeasurable aspects of "real-life budgeting," but it should greatly supplement current methods.

Management's Role

Common Goals

In order for a work measurement system to be fully appreciated and totally effective there must be a clear statement and understanding of the system's goals. The identification and understanding of work measurement goals and objectives must be on a common basis between the staff (work measurement, budget, and systems and procedures personnel) and line officials, including the working supervisors. The line people and the staff people do not always recognize the same advantages or limitations of work measurement. However, both the line and the staff generally see the same general values in a work measurement system, only in a somewhat different light and expressed in different terms. By effective communication and acceptance of proper responsibilities on the part of both line and staff the following "musts" for an integrated work measurement system can be achieved.[1]

> The system must be developed with the help of all levels of line management and must be designed for their use.

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[1] BuBud, <u>A Work Measurement System</u>, <u>op. cit</u>., p. 7.

The system must receive the continued support of each level of management, starting from the top.

The system must be kept on a current basis to meet changing operating conditions.

Top Management Support

The role of management in a successfully integrated work measurement system must be equally active and supporting at management levels above the activity. The support and interest must again come from the line managers--those managers who are in a position to ensure system integration at the highest level. Strong central policy concerning work measurement system design and application must originate from the highest organizational level. An example of this type of policy guidance is the DOD DIMES directive referred to in Chapter IV. Although this document may not provide all that is necessary for the integration of the various work measurement systems, it is illustrative of the type of effort that is required to achieve understanding and coordination at the management levels above the field activities. System direction and control, including general procedures, must be effectively accomplished at appropriate headquarters level with the same commonality of understanding and purpose between line and staff as required in the field. Technical support and periodic system audits should be provided by work measurement staffs established above the field level.

Recognition of Human Behavior

In recent years there has been increasing interest in the human behavior aspects of work measurement and the worker. Dr. Rensis Likert and Professor Chris Argyris, both established members of the human behaviorist school, have directed management attention to the effects of measurement on worker attitudes and morale and on management practices.

Dr. Likert, in his New Patterns of Management, pointed out that many organizations have inadequate measurement processes in that these processes leave large gaps in the amount and kind of information available to executives.[1] He states that too little attention is given to the measurement of variables that reflect the current condition of the internal state of the organization: its loyalty, skills, motivations, and capacity for effective interaction, communication and decision-making.[2] In failing to give proper attention to these variables and stressing end-result variables such as productivity, a cost is incurred that represents the human assets of the organization. Likert explains:

> In the company we studied, for example, the cost was clear: hostilities increased, there was greater reliance upon authority, loyalties declined, motivation to produce decreased while motivation to restrict production increased, and turnover increased. In other words, the quality of the human organization deteriorated as a functioning social system devoted to achieving the institution's objectives.[3]

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[1]Rensis Likert, New Patterns of Management (New York: McGraw-Hill Book Company, Inc., 1961), p. 61.

[2]Ibid. [3]Ibid., p. 71.

Likert also stresses that because they lack adequate measurements, managers and supervisors unwittingly make mistakes. He provides an example:

> A supervisor who at present receives information only on the quantity and quality of work turned out may be in serious error when trying to improve quality. If the low quality of the work is due to hostility toward him, any step he takes to put pressure on his subordinates to improve quality may result in an immediate short-run improvement. But the increase in hostility toward him as a consequence of this pressure is likely to lead to further long-run decreases in quality at every opportunity which the subordinates feel they can safely seize.[1]

Likert emphasizes the importance of detecting adverse changes in situations as early as possible so that effective steps can be taken before these changes produce serious problems. He recommends periodic measurements of perceptions, attitudes, expectations, motivations, and similar variables to provide advance indicators of changes in behavior that are likely to follow. These measurements can also yield valuable information about the course of any adverse trends and may indicate the kinds of corrective action most likely to bring about desired improvement.

Professor Argyris has examined the impact of tighter management controls on employees. These "controls" are defined to include management activities and tools such as planning,

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[1] *Ibid.*, p. 74.

organizing, systems, procedures, methods and standards.[1] Argyris states that management controls tend to make the employees feel dependent, passive, and subordinate to management.[2] As a result of controls, they experience pressure, interdepartmental strife, psychological failure, lack of control over their work environment, barriers to communication between the staff people and the line people, and pressure to be department-centered rather than organization-centered. Argyris uses his analysis of management controls and their effect on employees to support his more basic contention concerning the formal organization and dynamic directive leadership. Regardless of purpose, this recognition of the impact management controls can have on employees and their behavior further supports the need to be concerned with human behavior when evaluating management control systems.

It is important for managers to fully understand and appreciate the significance of the human behavior aspects of management systems such as work measurement. Consideration should be given to the effects that measurement and control have on the worker, his perception, attitudes and morale. Greater recognition of these factors and their importance in achieving improved overall organizational performance should be given by management when designing, implementing, and utilizing an integrated work measurement system.

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[1] Chris Argyris, Personality and Organization (New York: Harper & Brothers, 1957), p. 132.

[2] Ibid., p. 137.

Summary

The projection of a fully integrated work measurement system is developed to illustrate the essential elements and uses of a work measurement system that is literally a "management" system. A skilled work measurement staff, an effective methods improvement program, and a balanced approach to establishing work standards are fundamental elements of a sound work measurement system. The need for effective systems interface is paramount, especially with the quantity of data automation available and required in current systems application.

An integrated work measurement system is capable of providing management effective means for manpower utilization and control. At the same time the system provides the necessary man-hour, workload and performance data for activity budget formulation and execution. A third general use can be appreciated when work measurement data are assimilated into the management information system. This is achieved by data automation and the interfacing of data collection systems.

Management's role in achieving full work measurement integration is most significant in the area of recognition and support of common goals. Common goals between line and staff must be identified and accepted in order to obtain maximum utilization and effectiveness from the system. Recognition of the human behavior aspects of work measurement is important when designing, implementing and utilizing a work measurement system.

CHAPTER VI

CONCLUSIONS

1. There are several techniques available with which to effectively measure work and manpower performance in the Navy supply functions. These measurement and timing techniques have been successfully applied in industrial and business settings for many years. Since the early 1950's they have achieved a high degree of acceptance and extensive use in the government and particularly Navy supply areas. Considerable emphasis is currently being placed on the use of engineered time standards using standard time data as the basic tool of measurement. Both the DIMES and WGPMS are representative of this approach. Statistical measurement is still a necessary and effective technique used in performance type budget formulation and execution. The NAVSUP Work Measurement System is based on the statistical measurement concept. In the future, as data automation and computer applications increase, new methods of analyzing and controlling work and manpower will undoubtedly be developed. For the present, by maintaining adequately trained staffs, sufficient measurement techniques are available to effectively measure clerical, administrative and material handling type work.

2. There is presently some duplication of work measurement and reporting in the Navy supply functions. This duplication exists primarily in the warehousing functions where both DIMES and WGPMS performance standards are employed. One system, either DIMES or WGPMS, could be modified by restructuring the time data to provide the necessary basic measurement for both systems. This restructuring of standards will eventually occur and one set of time data will be used to measure the tasks in warehousing functions. Until this adjustment takes place activities will be confronted with some dual standards maintenance, reporting, and performance evaluation.

There is less duplication between the NAVSUP Work Measurement System and DIMES. DIMES measurement essentially complements the NAVSUP Work Measurement System by providing a detailed measure (on an engineered time basis) of the tasks and operations that comprise the functions measured statistically by the NAVSUP system. If the tasks and operations measured by DIMES standards are effectively controlled (manpower-wise) then the level of performance achieved will be reflected in the overall statistical measure (production rate). A similar situation exists between the WGPMS Composite Standards and the NAVSUP Work Measurement System.

3. A fully integrated work measurement system for Navy supply functions can be developed utilizing existing work measurement applications. (See Chapter V). The necessary components for a fully integrated work measurement system are

essentially in existence today:

a) Trained staffs support the DIMES and WGPMS systems.

b) Methods analysis and improvement are being emphasized in the DIMES program.

c) The measurement of work is increasingly being evaluated to effect a more economical balance between engineered and statistical performance measurement.

d) Under the NAVSUP Manpower Utilization and Control System, DIMES performance standards are being structured to provide a composite measurement at a common level of work definition--the job order.

e) Systems interface is also being accomplished by using the Job Order Number to collect and identify manpower performance data that can be used to uniformly and consistently support the NAVSUP Work Measurement System, DIMES and, where applicable, WGPMS.

f) Present work measurement systems (DIMES and the NAVSUP Work Measurement System) provide measures of past performance based on engineered and statistical work standards. A fully integrated work measurement system utilizing the NAVSUP MUACS approach will provide management (supervision) with an improved capability for using work standards to forecast manpower requirements and control manpower assignments.

g) The NAVSUP MUACS further supports the development of an integrated work measurement system by providing for the one-time input of common data for a variety of management reports--all reports being based upon various arrays of the same input data (i.e., DIMES, WGPMS, and the NAVSUP Work Measurement System).

h) The NAVSUP MUACS supports the integrated work measurement system concept of systems interface with overall management information requirements. MUACS can provide manpower and workload data from a computerized data bank for many management information purposes beyond the immediate use at activity level for control of manpower utilization.

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